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NOTES ON NORTH AMERICAN DROSOPHILIDAE WITH DESCRIPTIONS OF TWENTY-THREE NEW SPECIES.

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The writer has in preparation a comprehensive treatment of the North American species of Drosophila and closely related genera. This paper is not yet ready for publication; but there are several unnamed species that are being used as laboratory animals, so it has seemed advisable to put out a preliminary paper describing these and other new forms, and revising the names of a few additional species.

In the following descriptions there are a few terms that will need explanation. The "number of rows of acrostichal hairs" is to be counted just in front of the anterior pair of dorsocentral macrochætæ. The "costal index" is the number obtained by dividing the length of the second section of the costa by that of the third section; the "4th vein index" is obtained by dividing the length of the ultimate section of the fourth vein by that of the penultimate section; the "5x index" is obtained by dividing the length of the last section of the fifth vein by the length of the posterior cross-vein; the "4c index" is obtained by dividing the length of the third section of the costa by that of the penultimate section of the fourth vein. These indices are somewhat variable, but nevertheless are sufficiently characteristic to be valuable aids in classification. I hope later to publish some detailed data on their variability.

In the cases of four new species (*Drosophila virilis, robusta melanica, and modesta*) I have reared offspring from the individual selected as the type specimen. In these cases the mate, to which the type was bred, is designated allotype; and all descendants of the type are called *gonotypes*.

My studies have been greatly facilitated by loans of material and other favors received from Dr. F. E. Lutz, Messrs. C. W. Johnson and F. Knab, and Profs. J. M. Aldrich and A. L. Melander, and others. To them I wish to express my most sincere thanks.

The type specimens of the new species described here are in the following collections:

American Museum of Natural History, New York City:
Drosophila ramsdeni, saltans, earlei, virilis, robusta, melanica, melanissima, affinis, caribea, cardini, modesta, putrida, florœ, lutzii, prognatha, quadrata.

United States National Museum, Washington, D. C.:
Drosophila sulcata, pseudomelanica, orbitalis, superba, projectans.

A. L. Melander:
Drosophila melanderi.

J. M. Aldrich:
Chymomyza aldrichii.

Many paratypes are in the author's collection, in the four named above, and in other collections.

Leucophenga Mik. 1886. Wien. Ent. Zt. 317.

Drosophila maculosa Coq. 1895, Proc. Acad. Nat. Sci. Phila. XL, is a synonym of *L. quadrimaculata* Walk. 1856, Dipt. Saund. IV. The species will be easily recognized by its large flat yellow palpi. I have seen specimens from New York, District of Columbia, North Carolina, Florida, Cuba, Dominican Republic, Peru. These include Coquillett's type.

Drosophila bimaculata Lw. from Cuba, is a *Leucophenga*. I have examined Loew's specimen in the Museum of Comparative Zoology at Harvard, and two Cuban specimens in my own collection.

"*Leucophenga vittata* Coq." of Johnson, 1913, Bull. Am. Mus. Nat. Hist. XXXII. 88 is a *Scaptomyza*. (See below).

Chymomyza Czerny. 1903. Zts. Hymenopt. III.

This genus has not hitherto been reported from North America, but *Drosophila amœna* Lw. and *D. procnemis* Willist. both belong here. The genus is easily separable from *Drosophila* in that it has bare eyes; small postvertical bristles; second orbital small or missing; a fourth orbital, below the third, large, and reclinate; prominent male genitalia. The species are usually rather slender, often with pigmented wings, and have the habit of waving their wings. They are frequently found around bleeding trees, but *C. amœna* and *C. procnemis* will breed on fermenting fruit. *C. amœna* is frequently collected with the sweeping net, and is often very common around tomatoes and windfall apples. It is also often seen on windows. *C. procnemis* occurs from New York to Trinidad and Panama.

C. caudatula Oldenberg, 1914, Arch. Naturgesch. LXXX, A. Heft 2, 14, was described from Herkulesbad, in the southern Carpathians. Prof. Melander lent me two specimens, collected at Pullman and at Mt. Constitution, both in Washington. I have carefully compared these specimens with Oldenberg's very full description, and can find no significant difference, even in the external male genitalia. There is, so far as I am aware, no other record of the species.

The three species above, with the new one described below, may be separated by the following key:

1. Wings much spotted; front legs yellow.....*C. amœna* Loew.
   Wings clear, or blackish along anterior margin, or with a white tip; front femora, tibiæ, and first tarsal joints blackish.....2
2. Front dark opaque brown.....3
   Front yellow or reddish yellow.....*C. procnemis* Williston
3. Wings clear; face whitish.....*C. caudatula* Oldenberg
   Costal cell brown; face brown.....*C. aldrichii* n. sp.

Chymomyza aldrichii, n. sp.

♂. Arista with four branches above and two below. Antennæ reddish brown. Front nearly one-half width of head, wider above; reddish brown, orbits and triangle darker. Second orbital reduced to a minute hair, the other three approximately equal in size. Carina very small and confined to upper part of face. Face brown, somewhat concave. There is a row of bristles on the oral margin, the anterior one being slightly longer than the others. Cheeks yellow. Eyes bare.

Dorsum of thorax and scutellum shining dark reddish brown. Pleuræ brownish yellow. Coxæ and legs pale yellow, except as follows; fore femora and tibiæ dark brown, fore tarsi and hind tibiæ brownish yellow.

Abdomen shining black, hypopygium prominent.

Wings brownish on anterior margin, especially in costal cell. Costal index about 1.9, 4th vein index about 2.6, 5x index about 2.0, 4c index about 0.6.

Length of body 2¼mm., wings 2½mm.

Type and 7 paratypes, collected at Potlatch, Ida., Sept. 9, 1912, on the windows of a sawmill (J. M. Aldrich). Also one specimen, Yale, Ida., Sept. 10, 1912 (Aldrich). The type and 5 paratypes have been returned to Prof. Aldrich.

Scaptomyza Hardy, 1849. Proc. Berwicksh. Nat. Club, 349.

This genus is easily recognized, in our American species, by the 2 or 4 acrostichal rows. The larvæ are not exclusively leaf miners, as I have bred *S. adusta* Lw. and *S. graminum* Fall. through several generations on tomato fruits and also on potato tubers.

Our species have been separated largely on the basis of the thoracic color and the presence or absence of the spot at the tip of the wings. Both characters are extremely unreliable, however, as neither the dark thorax nor the wing spot appears until a day or two after the adult emerges. The genus is easily divided into two groups on the basis of the number of rows of acrostichal hairs. *S. adusta* Lw. and *S. terminalis* Lw. have 4; *S. graminum* Fall. has 2.

S. flaveola Meig. probably does not occur in North America. Most specimens so labelled seem to be immature specimens of the three above named species. *S. vittata* Coq. 1895 Proc. Acad. Nat. Sci. Phila. 318, is perhaps a synonym of *S. graminum* Fall. Geomyz. 8. I have been unable to find the type specimen of *vittata*. There are some tropical species belonging to the two-rowed group, but I have not described them because of my uncertainty as to most of this genus.

S. apicata Thoms. 1868, Eug. Resa. 597, is probably a synonym of *S. terminalis* Lw. 1863, Berl. Ent. Zt. I have examined a very large series of this form from the Pacific Coast and from Canada and New England, including Loew's specimen. It is extremely variable in several characters (size, color, wing-markings) and there may well be several species involved. Some specimens are practically indistinguishable from *S. adusta* Lw.; but that species is not especially variable, and is

much lighter in color than most *S. terminalis*. I have seen specimens of *S. adusta* from Massachusetts, Alabama, Texas, Illinois and numerous intermediate states.

Drosophila Fall, 1823. Geomyz, 4.

The following new names are proposed, those now in use being preoccupied (homonyms).

Drosophila annularis, nom. nov. for **D. annulata** Willist. 1896. Trans Ent. Soc. Lond. Not **Notiphila annulata** Fall. 1813. Vetensk. Akad. Hand.; **Drosophila annulata** Zett., 1847. Dipt. Scand. VI.

Drosophila nebulosa, nom. nov. for **D. limbata** Willist. 1896. Trans. Ent. Soc. Lond. Not **Drosophila limbata** v. Ros. 1840. Württ. Corrbl. The species occurs in Porto Rico, Cuba, Dominican Republic, Barbadoes, Panama.

Drosophila pulchella, nom. nov. for **D. bellula** Willist. 1896. Trans. Ent. Soc. Lond. Not **Drosophila bellula** Bergr. 1894. Ent. Zt. Stett. LV.

Drosophila willistoni, nom. nov. for **D. pallida** Willist. 1896. Trans. Ent. Soc. Lond. Not **Drosophila pallida** Zett. 1847. Dipt. Scand. VI. This species is found in Florida (Miami), Cuba, Jamaica, Hayti, Porto Rico, Bahamas, British Honduras, Costa Rica, Panama and at Manaos, Brazil (?).

Drosophila multipuncta, Lw. 1866. Berl. Ent. Zt. X. is a synonym of **D. guttifera** Walk. 1849. List. Dipt. Ins. IV. I have examined the Loew specimen in the Museum of Comparative Zoology at Harvard, and a large series of more recent material from Massachusetts, New Jersey, North Carolina, Indiana, Alabama and Texas.

Drosophila ornatipennis, Willist. 1896. Trans. Ent. Soc. Lond. is a synonym of **D. calloptera** Schiner. 1868. Novara. I have examined Williston type material in the American Museum of Natural History, and specimens that I collected in Cuba.

"Drosophila slossonæ Coq." of Johnson. 1913. Bull Am. Mus. Nat. Hist. XXXII. 88, is a manuscript name, and I have been unable to find any specimen bearing this label.

Drosophila obscura Fall., a common European species, occurs on the Pacific coast. I have examined specimens from Corvallis, Oregon, Claremont and Newport, California. These agree with European material determined by Bezzi and by de Meijere, and with the descriptions given by Schiner and by Oldenberg. The Japanese specimens referred to this species by Coquillett (1899. Proc. U. S. N. M. XXI. 301) are not very well preserved, but I am convinced that they belong to some other species.

Drosophila ramsdeni, n. sp.

♀. Arista with 4 branches above and 2 below. Antennæ pale yellow, third joint reddish brown above. Front pale yellow, 3 brown spots on each orbit, and one around each ocellus. Second orbital one-fourth size of other two. Vibrissa three times size of other oral bristles. Carina large, broad, sulcate. Face and cheeks yellow, a brown spot just below carina; and one just below each eye. Eyes with black pile.

Eight acrostichal rows, no prescutellar bristles. Dorsum of thorax light gray, each hair and bristle arising from a dark brown spot. Between the dorsocentrals these spots are fused into a pair of irregular longitudinal stripes. Scutellum light gray, basal pair of bristles arising from brown spot. Pleuræ dark brown above, pale yellow below. Legs pale yellow, tips of femora and bases of tibiæ brown. Apical and preapical bristles on first two pairs of tibiæ, preapicals on third.

Abdomen yellow; each segment with a dark brown cross band, which is broadly broken in the median dorsal line.

Wings clear; veins pale brown, with dark brown spots at tip of first section of costa and at junction of first and second veins. Costal index about 2.6, fourth vein index about 2.0, 5x index about 1.2, 4c index about 1.1.

Length of body 2½mm., wings 2½mm.

Type and paratypes, from pineapple, sent from Guantanamo, Cuba, by Mr. Chas. T. Ramsden, Dec. 1913. The type itself was bred, from this stock, in New York City, Feb., 1914.

The males agree with the above description in all respects.

This species resembles *D. repleta* Woll., but is easily separated from it on the basis of its banded legs, lighter color, and more slender form.

D. ramsdeni is the "Species A" of Metz (1914, Journ. Exper. Zool. 17, p. 50).

Drosophila saltans, n. sp.

♂. Arista with 5 branches above and 3 below. Antennæ brown, third joint darker. Front over one-third width of head, wider above; reddish brown, triangle and orbits grayish pollinose, with a brown spot above upper orbital bristle. Second orbital one-fifth other two. Second oral bristle nearly as long as first. Carina high and narrow. Face brown, proboscis brownish. Cheeks yellowish brown, their greatest width scarcely one-sixth greatest diameter of eyes. Eyes with short sparse dark pile.

Acrostichal hairs in six rows; no prescutellars. Dorsum of thorax grayish brown pollinose, with markings of dark dull brown as follows: a pair of short longitudinal stripes on the front margin, just within the dorso-central row of hairs; two pairs of spots just outside the dorso-central row, one just behind the humeri and the other just behind the transverse suture. Scutellum grayish brown pollinose. Pleuræ dark

brown, grayish at the sutures. Legs pale brown, femora and tibiæ darker in the middle. Apical and preapical bristles on first and second tibiæ, preapicals on third.

Abdomen dark brown, each segment grayish pollinose anteriorly.

Wings with a small blackish speck at tip of first vein. Costal index about 2.0; 4th vein index about 2.6; 5x index about 1.7; 4c index about 1.4. Length of body 1½mm., wings 1¾mm.

Type and ten paratypes, from stock bred in New York City, from a pineapple sent from Guantanamo, Cuba, by Mr. Chas. T. Ramsden. Four specimens from Panama, R. P., differ only in that the dorsum of the thorax is lighter, and may be referred to this species.

The name *saltans* is given because the larvæ (like those of *D. cardini*, n. sp.), have the habit of "skipping" as do those of *Piophila casei* Linn. and by the same mechanism.

The species may be recognized by its thoracic pattern, small size and 6 acrostichal rows.

Drosophila earlei, n. sp.

♂. Arista with five branches above and two below. Antennæ brown, third joint dark. Front over one-third width of head, wider above; opaque reddish brown, orbits and triangle grayish pollinose. Second orbital one-third other two. Second oral bristle nearly as long as first. Carina high and narrow; face brown. Cheeks yellowish brown; their greatest width about one-sixth greatest diameter of eyes.

Acrostichal hairs somewhat irregular, in six to eight rows; no prescutellars. Dorsum of thorax coffee brown, with yellow-brown markings as follows: a narrow median longitudinal streak, a pair of stripes including the dorsocentrals and broader anteriorly with external branches behind, a spot on each humerus. Scutellum coffee brown, with yellowish lateral edges. Pleuræ coffee-brown; legs pale brown. First and second tibiæ with apical and preapical bristles, third with preapicals.

Abdomen black, four basal segments, each with an interrupted yellowish anterior band.

Wings clear, veins brown. Costal index about 2.0; 4th vein index about 1.7; 5x index about 1.3; 4c index about 0.9.

Length of body 1¾mm., wings 2mm.

Type and two paratypes, Herradura, Cuba, January 28, 1915 (C. W. Metz). Other specimens are before me from Cristo, Cuba, and Panama, R. P. The females agree with the description given above. This species is named after Prof. F. S. Earle, on whose plantation the type material was collected.

This species will be most easily confused with *D. saltans* n. sp. It differs in its larger size, yellow markings on abdomen, thoracic pattern, and smaller 4th vein index.

Drosophila sulcata, n. sp.

♂. Arista with five branches above and two below. Antennæ reddish brown, third joint dark. Front over one-third width of head, reddish brown, with a dark brown ocellar dot. Second orbital about one-fourth other two. Second oral bristle not quite one-half first. Three large bristles on each palpus. Carina prominent, not very broad, distinctly sulcate. Face reddish brown. Cheeks reddish brown; their greatest width about one-fifth greatest diameter of eyes. Eyes with rather short sparse pile.

Acrostichal hairs in six rows; no prescutellar bristles. Dorsum of thorax grayish pollinose, with somewhat indefinite and variable reddish brown interrupted stripes. Scutellum grayish pollinose. Pleuræ grayish pollinose, reddish brown below. Legs, including coxæ, pale reddish brown. Apical and preapical bristles on first and second tibiæ, preapicals on third.

Abdomen grayish, with a dark brown fascia on each side of each segment, leaving usually only a median dorsal and a posterior gray line.

Wings slightly yellowish, veins brown. Costal index about 4.6; 4th vein index about 1.3; 5x index about 0.9; 4c index about 0.7.

Length of body 3mm., wings 3¼mm.

Type and 8 paratypes collected at Cabin John Bridge, Md., April 1914, (3 at sap), by R. C. Shannon (U. S. N. M.). Other specimens have been examined as follows: Dead Run, Fairfax County, and Glencarlyn, Va.; Linnieville, Md.; D. C.; Ottawa, Can.; Pottstown, North Mt., Pa.; Chester, Mass.; Franconia, Hanover, and Bretton Woods, N. H.; Ga.

The females agree with the above description, but the thoracic color is variable in both sexes and is easily obscured in imperfect specimens.

The clearly sulcate carina, large size, six acrostichal rows, and grayish thorax will serve to distinguish this species from any others known to me.

Drosophila virilis, n. sp.

♂. Arista with five branches above and two below. Antennæ brown, third joint dark opaque reddish brown. Front over one-third width of head, wider above; dull coffee brown, ocellar dot black. Second orbital one-third size of other two. Second oral bristle three quarters length of first. Only one long bristle on each palpus. Carina broad, slightly sulcate, nose-like. Face somewhat shiny brown. Width of cheek over one-fourth greatest diameter of eye. Cheeks yellowish brown.

Six acrostichal rows; no prescutellars. Dorsum of thorax and scutellum dark dull brown. Pleuræ and abdomen dull brown, somewhat darker. Legs brown, paler than thorax; no combs on first tarsal joints; preapicals on all tibiæ, apicals on the first two pairs.

Wings clear, veins brown. Costal index about 3.0, 4th vein index about 1.8, 5x index about 1.2, 4c index about 0.9.

Length body 2¾mm., wings 3mm.

Type, allotype and gonotypes from New York, N. Y. The type and allotype were bred from a pineapple exposed at Columbia University; they and their descendants are the only specimens of the species that I have seen. The females agree with the above description.

This is the "species B" of Metz (1914 Journ. Exper. Zool. 17, p. 50; 1915. Am. Nat. 49, p. 187). It is a fruit eating form, and has been kept in the laboratory more than two years, banana being used for food.

The species resembles *D. robusta* n. sp. and *D. melanica* n. sp. rather closely. The six acrostichal rows will separate it from most specimens of *D. robusta;* and from both these species it may be distinguished by its broad cheeks and relatively long second oral bristle.

Drosophila robusta, n. sp.

♂. Arista with six branches above and three below. Antennæ dark brown, second joint pollinose distally. Front over one-third width of head; dark coffee brown, orbits and triangle slightly grayish pollinose. Second orbital fine, about one-fourth length of other two. Second oral bristle not quite one-half size of vibrissa. More than one prominent bristle on each palpus. Carina broad, very slightly sulcate. Face somewhat shining, brown. Cheeks brown, their greatest width scarcely one-sixth greatest diameter of eyes. Eyes with short black pile.

Acrostichal hairs somewhat irregular, in six to eight rows; no prescutellar bristles. Dorsum of thorax dark dull brown, with four faint pollinose longitudinal stripes. Scutellum and pleuræ dark dull brown. Legs pale brown; fore coxæ blackish brown beneath, with a whitish pollinose spot between them. Apical and preapical bristles on first and second tibiæ, preapicals on third.

Abdomen grayish brown, each segment with a very broad dark brown fascia on each side; these fasciæ often nearly or quite meet in the middorsal line.

Wings clear; veins brown, subterminal part of first vein very dark. Costal index about 4.0, 4th vein index about 1.6, 5x index about 1.2, 4c index about 0.7.

Length body 2½mm., wings 2¾mm.

Type, allotype and numerous gonotypes, bred in New York, N. Y., from stock obtained at Kushla, Alabama. I have examined specimens of this species from Woods Hole, Mass.,

Cold Spring Harbor, Long Island, and Ithaca, N. Y., Cabin John Bridge, Md., Falls Church, Va. and Helena, Ark.

The females agree with the description given above; but both sexes vary somewhat in the color of the thorax, and many specimens have the posterior cross-vein distinctly clouded.

Drosophila robusta is a fruit eating form, living on banana in the laboratory. I have specimens bred from potato in Massachusetts.

This species resembles *D. virilis*, n. sp. and *D. melanica*, n. sp. Its oral and palpal bristles and narrow cheeks will separate it from the former. It differs from *D. melanica* in its larger size, black fore coxæ, and darker abdomen.

Drosophila melanica, n. sp.

♂. Arista with four branches above and two below. Antennæ dark brown, second joint grayish above. Front over one-third width of head, wider above; blackish, velvety, orbits and narrow triangle brown. Second orbital about one-third size of other two. Second oral bristle less than one-fourth vibrissa. Carina broad, slightly sulcate. Face blackish brown, dull. Several prominent palpal bristles. Cheeks brown; their greatest width about one-sixth greatest diameter of eyes. Eyes with short thick black pile.

Acrostichal hairs long, in six rows; no prescutellar bristles. Dorsum of thorax dull blackish brown, a small indistinct pair of brown spots on anterior margin, just inside of dorsocentral lines. Humeri grayish brown. Scutellum and pleuræ dark dull blackish brown. Legs, including coxæ, pale brown. Apicals and preapicals on first and second tibiæ, preapicals on third.

Abdomen yellow, with a pair of lateral dark brown fasciæ on each segment.

Wings clear, veins brown. Costal index about 3.8; 4th vein index about 1.4; 5x index about 1.0; 4c index about 0.8.

Length of body 2mm., wings 2¼mm.

Type, allotype and numerous gonotypes, bred at New York, N. Y., from stock collected at Kushla, Alabama, April, 1915. I have examined specimens from Woods Hole and Plymouth, Mass.; Macon, Ga.; St. Louis, Mo.; Kingston, R. I.; Plummer's Island and vicinity, Md.; Dead Run, Va.; North Carolina; Mt. Washington, N. H.; Helena, Ark.

Typical females agree with the above description. Some specimens of both sexes, especially the northern ones, are somewhat lighter in color; but this is perhaps an accidental age difference.

The species resembles *D. virilis*, n. sp., *D. robusta*, n. sp., and *D. affinis*, n. sp. The narrow cheeks and small second oral bristles distinguish it from *D. virilis;* the small size, brown fore coxæ and yellow markings on abdomen from *D. robusta;* absence of combs on male tarsi, broad carina and darker thorax from *D. affinis*. The features that distinguish *D. melanica* from *D. melanissima*, n. sp. and *D. pseudomelanica*, n. sp. are discussed under those species.

D. melanica is the "species C" of Metz. (1914, Journ. Exper. Zool. 17, p. 52).

Drosophila melanissima, n. sp.

♂. Arista with four branches above and two below. Antennæ velvety black. Front about one-half width of head, wider above; blackish brown, velvety. Second orbital about one-third other two. Second oral bristle less than one-fourth vibrissa. Carina broad, slightly sulcate below. Face black. Several prominent palpal bristles. Cheeks brownish black; their greatest width about one-third greatest diameter of eyes. Eyes with short thick black pile.

Acrostichal hairs long, in six rows; no prescutellars. Dorsum of thorax, scutellum and pleuræ brownish black; there is a faint grayish pollinose line extending from the base of the fore coxa to the base of the halter. Legs blackish brown; apical and preapical bristles on first and second tibiæ, preapicals on third.

Abdomen dark blackish brown, slightly polished.

Wings slightly brownish, veins brown. Costal index about 4.0; 4th vein index about 1.7; 5x index about 1.1; 4c index about 0.7.

Length of body 2mm., wings 2¼mm.

Type collected at Kushla, Alabama, June 22, 1914. In the U. S. National Museum are specimens from Biscayne Bay, Florida, Georgia, and North Carolina. The females among these agree with the above description.

This species is very similar to *D. melanica*, n. sp., and might be considered a color variety of it but for the smaller eyes, broader cheeks and larger oral opening. In color it is decidedly darker than *D. melanica*.

Drosophila pseudomelanica, n. sp.

♂. Arista with five branches above and three below. Antennæ brown. Front about one-third width of head, wider above; brownish red. Second orbital scarcely more than a hair. Second oral bristle two-thirds size of first. Carina flat, rather narrow. Face narrow, brown. Palpi brown, with several prominent bristles. Cheeks brown; their greatest width about one sixth greatest diameter of eyes. Eyes with short pile.

Acrostichal hairs in six rows; no prescutellars. Dorsum of thorax and scutellum dull blackish brown; pleuræ brown. Legs pale yellowish brown; apical and preapical bristles on first and second tibiæ, only preapicals on third.

Abdomen shining dark brown, basal segments with lighter median dorsal and anterior lines.

Wings clear, veins brown. Costal index about 4.0; 4th vein index about 1.8; 5x index about 1.3; 4c index about 0.7.

Length of body 1½mm., wings 1¾mm.

Type and two paratypes. Dead Run, Fairfax County, Va., April, 1914 (R. C. Shannon). One specimen, Cabin John Bridge, Md., March, 1914. (Shannon).

This species may be distinguished from *D. melanica*, n. sp. and the other members of its group by the two large oral bristles, narrow face and front and small size.

Drosophila affinis, n. sp.

♂. Arista with five branches above and two below. Antennæ brown, third joint nearly black. Front nearly one-half width of head, wider above; dark brown, lighter below, orbits and triangle pollinose. Second orbital three-fourths third, which is three-fourths first. Carina low, very narrow above; face dull brown. Second oral bristle scarcely one-fifth first. Cheeks grayish brown, their greatest width about one-sixth height of eyes. Eyes with short pile.

Acrostichal hairs in six rows; no prescutellars. Dorsum of thorax, scutellum, and pleuræ coffee brown. Legs pale brownish yellow. Apical and preapical bristles on first and second tibiæ, preapicals on third. A comb-like row of black bristles on the inner anterior surface of the first tarsal joint of each front leg, as in the male of *D. melanogaster* Meig.

Abdomen very dark brown, lighter toward the base.

Wings clear. Costal index about 3.6; 4th vein index about 2.6; 5x index about 2.0; 4c index about 1.2.

Length body 2mm., wings 2¼mm.

Type bred from banana, Kushla, Alabama, April 25, 1915. Twelve paratypes, Kushla, Alabama. The females agree with the above description, except that they have no combs on the first tarsi. I have examined numerous specimens from the United States, the following states being represented: Massachusetts, New York, New Jersey, Indiana, Alabama, Texas, Illinois, Pennsylvania, Missouri, Oklahoma, New Hampshire, District of Columbia, Maryland, Georgia, North Carolina and Virginia.

The species may be separated from *D. melanogaster* Meig. on the basis of its color and its six acrostichal rows (*D. melanogaster* has eight). *D. obscura* Fall. also has eight rows and has combs on the second tarsal joints of the front legs of the male, as well as on the first. The females may be confused with *D. melanica*, n. sp., but the narrow carina will serve to identify them as *D. affinis*. Most of the material that has passed as *D. confusa* Staeg. in this country belongs to *D. affinis*.

Drosophila caribea, n. sp.

♂. Arista with five branches above and three below. Antennæ yellow; third joint brownish. Front nearly one-half width of head, wider above; reddish yellow. Second orbital about one-third other two. First oral bristle one and one-half times second. Carina rather broad, flat. Face, cheeks and proboscis yellow. Greatest width of cheeks less than one-sixth greatest diameter of eyes. Eyes thickly set with short yellow pile.

Acrostichal hairs in eight rows; no prescutellar bristles, although there is a transverse row of about four slightly enlarged hairs between the posterior pair of dorsocentrals. Dorsum of thorax, scutellum and pleuræ dull reddish yellow. Legs pale yellow. Apical and preapical bristles on first and second tibiæ, preapicals on third.

Abdomen brownish yellow, each segment with an indistinct dark brown posterior margin.

Wings clear. Costal index about 1.5; 4th vein index about 2.4; 5x index about 2.0; 4c index about 1.6.

Length body about 2mm., wings 2¼mm.

Type and eleven paratypes, Havana, Cuba, 1915. Other specimens have been examined from Santiago de Cuba, Santiago de las Vegas, Guantanamo, Herradura, Baracoa, Cuba; Sanchez, R. Dom.; Mayaguez, P. R.; Antigua; Roseau, Dominica; Manaos, Brazil; Panama, R. P.; San Jose, Costa Rica; Punta Gorda, Br. Honduras. This form is quite common in Cuba and Central America, about fruit, on which it breeds. It is also attracted to excrement.

The species is similar to *Drosophila melanogaster* Meig., but it may be recognized by the absence of tarsal combs in the male, paler abdomen, and higher costal and 4c indices. From *D. willistoni* nom. nov. it may be distinguished by the eight acrostichal rows (*D. willistoni* has only six), duller color and stouter shape.

Drosophila orbitalis, n. sp.

♂. Arista with five branches above and three below. Antennæ yellow. Front slightly over one-third width of head, wider above; yellow brown, orbits grayish. Orbitals, as well as other frontal bristles, small; second nearly as large as other two, situated half way between them. Carina prominent, narrow, not sulcate. Face grayish yellow. Only one prominent oral bristle. Cheeks yellow, their greatest width about one-eighth greatest diameter of eyes. Eyes clothed with short pale pile.

Acrostichal hairs in eight rows; no prescutellars. Dorsum of thorax and scutellum polished reddish yellow. Pleuræ and legs yellow. Apical and preapical bristles on first and second tibiæ, preapicals on third.

Abdomen black; terminal segments yellow brown on anterior outer corners.

Wings clear; costal index about 2.6; 4th vein index about 1.3; 5x index about 1.0; 4c index about 0.8. Third and fourth veins slightly convergent.

Length body 2mm., wings 2¼mm.

Type and paratype, Taboga Island, Panama, July, 1907. (Aug. Busck). U. S. Nat. Museum Collection.

The short, subequal, widely separated orbitals will distinguish this species from *D. melanogaster* Meig. and *D. caribea* n. sp., which resemble it rather closely.

Drosophila cardini, n. sp.

♂. Arista with five branches above and two below. Antennæ yellow, third joint brown. Front over one-third width of head, wider above; reddish yellow, orbits grayish. Second orbital about one-fifth other two. Carina broad and flat. Face brownish yellow, somewhat polished. Two prominent oral bristles, nearly equal. Cheeks yellow, their greatest width about one-fifth the greatest diameter of the eyes. Eyes clothed with short pale pile.

Acrostichal hairs in six rows; no prescutellars. Dorsum of thorax, scutellum and pleuræ shining reddish brown. Legs yellow; apical and preapical bristles on first and second tibiæ, preapicals on third.

Abdomen shining black; three basal segments with anterior bands of reddish brown, which do not reach the lateral margin.

Wings with small brownish clouds on each cross vein. Costal index about 3.9; 4th vein index about 1.7; 5x index about 1.0; 4c index about 0.9.

Length body 2½mm., wings 2½mm.

Type and twenty paratypes, Havana, Cuba, 1915. Specimens are before me from Santiago de las Vegas, Aguada Pasajeros, Herradura, Cristo, Cuba; Sanchez, R. Dom.; Mayaguez, Arecibo, Jayuya, Adjuntas, P. R.; Dominica, W. I.; San Jose,

Port Limon, Costa Rica; Panama, R. P.; Miami, Fla. The species is named for Sr. Patricio Cardin, of the Estacion Agronomico, Santiago de las Vegas, Cuba, through whose kindness Dr. C. W. Metz and I were enabled to collect some of the material of this and other species.

This species is quite variable in color, especially in the female sex. Many specimens are quite pale, and have little black on the abdomen. Dr. C. W. Metz and I have bred several stocks through many generations and have found these variations not to be inherited. They are, however, likely to cause confusion, since these pale females are practically indistinguishable from females of *D. similis* Willist. These two forms are quite distinct, as breeding experiments have shown, and we have been unable to cross them, but it is safest not to identify females as *D. similis* unless they have been bred, or the males are known.

Ordinarily the peculiar shining reddish brown thorax and shining black markings on the abdomen, together with the clouded cross veins, will serve to distinguish *D. cardini.*

I have found this species very common about fruit, on which it breeds, in Cuba and Central America. It is not at all rare in southern Florida.

Drosophila melanderi, n. sp.

♀. Arista with five short branches above and one below. Antennæ yellow, third joint red-brown. Front nearly one-half width of head, reddish yellow, triangle brown. Second orbital about one-fifth other two. One bristle and numerous hairs on oral margin. Carina low, flat and narrow. Face yellow. Cheeks yellow; their greatest width about one-fourth greatest diameter of eyes. Eyes with fine pale pile.

Acrostichal hairs in six rows; no prescutellars. Dorsum of thorax and scutellum somewhat shining reddish yellow. Pleuræ reddish yellow. Legs yellow. Apical and preapical bristles on first and second tibiæ, preapicals on third.

Abdomen dull yellow, each of first four segments with an interrupted posterior dark brown band.

Wings clear, veins brown. Costal index about 3.0; 4th vein index about 1.3; 5x index about 1.1; 4c index about 0.7.

Length body 2½mm., wings 3mm.

Type and one paratype, Tacoma, Washington, August 27, 1911 (A. L. Melander). One specimen, Mt. Constitution, Washington. The type is in Professor Melander's collection.

This species resembles the European *D. fenestrarum* Fall., but the acrostichal rows and abdominal pattern are sufficient to show that it is different. Among our American species it will be most readily confused with *D. transversa* Fall. and similar species. The clear wings, single oral bristle, short aristal branches and slender body and wings will serve to identify it.

Drosophila modesta, n. sp.

♂. Arista with about six branches above and three below. Antennæ pale brown, third joint dark. Front over one-third width of head, wider above; opaque yellow. Second orbital about one-fifth other two. Second oral bristle nearly as long as first. Carina broad, flat; face brownish yellow. Cheeks yellow; their greatest width scarcely equal to one-sixth greatest diameter of eyes. Eyes with yellow pile.

Six rows of acrostichal hairs; no prescutellar bristles. Dorsum of thorax dark dull yellowish brown. Pleuræ and legs pale yellowish brown. Apical and preapical bristles on first and second tibiæ, preapicals on third.

Abdomen shining yellow; an interrupted dark brown band on the posterior margin of each of the first four segments, and a median anterior dark brown spot on the third, fourth and fifth segments.

Wings with faint clouds on each cross vein and at the tips of second and third veins; veins dark brown. Costal index about 4.3; 4th vein index about 1.7; 5x index about 1.3; 4c index about 0.7.

Length body 2½mm., wings 2¾mm.

Type, allotype and gonotypes bred in New York, N. Y., from stock collected at Kushla, Alabama, April, 1915. I have also examined specimens from New Orleans, La.; Richmond, Arlington, Rosslyn, Dead Run, Va.; Plummer's Island, Md.; Bloomington, Ind.; New York, N. Y. The last specimens were bred from cabbage in November, and I am inclined to suspect were imported with the cabbage. I have also bred the species from banana, grape sap, agaric, and watermelon. The females agree in all respects with the description given above.

This species is similar to *D. tripunctata* Lw., but differs in its abdominal markings, and also in having six acrostichal rows, for *D. tripunctata* has eight. From *D. putrida* n. sp. it is easily separated by the absence of presutural acrostichal bristles; and from *D. transversa* Fall., by its two large oral bristles. The abdominal pattern and dull thorax will distinguish it from *D. quinaria* Lw.

Drosophila putrida, n. sp.

♂. Arista with five or six branches above and two below. Antennæ yellow brown, third joint dark reddish brown. Front nearly one-third width of head, wider above; yellow brown, dull; ocellar dot darker. Second orbital minute. Second oral bristle nearly as long as first. Carina low, rather broad, flat; face yellow brown, somewhat shiny. Cheeks yellow, about one-eighth as wide as greatest diameter of eyes. Eyes with fine light yellow pile.

Six acrostichal rows; no prescutellar bristles; a pair of presutural bristles in the acrostichal rows next to the outer ones. Dorsum of thorax and scutellum shining yellow. Pleuræ and legs pale yellow. Apical and preapical bristles on first and second tibiæ, preapicals on third.

Abdomen pale yellow, each segment with a brown band on posterior margin, interrupted in the median dorsal line.

Wings clear. Costal index about 2.8; 4th vein index about 1.6; 5x index about 1.2; 4c index about 0.8.

Length body 2mm., wings 2mm.

Type and paratypes, Woods Hole, Mass. Specimens examined from Vermont, Connecticut, Rhode Island, New York, New Jersey, Pennsylvania, Illinois, Virginia, North Carolina, Georgia, Alabama and Mississippi. The female agrees with the above description. The species is very common on fungi, in which it breeds.

Easily distinguished from all other members of the genus known to me by the presence of the presutural acrostichal pair of bristles. Some specimens are more brownish than the type.

Drosophila floræ, n. sp.

♂. Arista with four branches above and three below. Antennæ dull brown, third joint darker. Front about one-third width of head, wider above; dull yellowish brown. Second orbital one-half other two. Second oral bristle about one-third first. Carina broad, flat; face dull yellow brown. Cheeks yellow; their greatest width about one-eighth greatest diameter of eyes. Eyes with fine black pile.

Eight acrostichal rows; prescutellars well developed. Dorsum of thorax, scutellum and pleuræ dull brown. Legs pale brown; apical and preapical bristles on first and second tibiæ, preapicals on third.

Abdomen dark brown, basal segment with a yellowish brown transverse band.

Wings clear; costal index about 2.5; 4th vein index about 1.8; 5x index about 1.4; 4c index about 1.0.

Length body 2¼mm., wings 2½mm.

Type and paratypes, Havana, Cuba, January and February, 1915. Specimens have been examined from Guareiras, Cuba;

Naguabo, Porto Rico; San Jose, Costa Rica. The females agree in all respects with the above description. The species is usually found in flowers of Datura, melons, etc. on the decaying petals of which it breeds.

The well developed prescutellar bristles, clear wings and dull brown color will be sufficient to distinguish this species from any others known to me.

Drosophila lutzii, n. sp.

♂. Arista with four short branches above and two below. Antennæ yellow brown. Front over one-third width of head, wider above; opaque dark brown, orbits and triangle polished. Second orbital about one-fourth other two. Only one large oral bristle. Carina rather broad, flat, edges sharply angled; face brown. Cheeks brown, their greatest width about one-fifth height of eyes. Eyes with short sparse pile.

Six rows of acrostichal hairs; no prescutellar bristles. Dorsum of thorax, scutellum and pleuræ dark reddish brown, somewhat polished. Legs pale yellowish brown, femora somewhat darker. Apical and preapical bristles on first and second tibiæ, preapicals on third.

Abdomen yellowish brown, lighter towards tip.

Wings clear, veins yellowish. Costal index about 2.1; 4th vein index about 1.7; 5x index about 1.3; 4c index about 1:1.

Length body 1¾mm., wings 1½mm.

Type and four paratypes (♂ and ♀), collected at Havana, Cuba, January, February, 1915. The species is very common in many parts of tropical America. I have examined specimens from Guane, Cristo, Havana, Aguada Pasajeros, Guareiras and Guantanamo, Cuba; Hope Gardens, Jamaica; Naguabo, Mayaguez and Adjuntas, Porto Rico; Port Limon, Costa Rica; Biscayne Bay, Key West, and Miami, Florida. It is found in flowers, especially those of Datura, and breeds on the decaying petals. The female agrees with the above description of the male.

The species will be easily known by its small size, shining reddish brown color and short bristles.

Drosophila prognatha, n. sp.

♂! Arista with six branches above and two below. Antennæ yellow, third joint very long and covered with yellow hairs. Front over one-third width of head, dull yellow, ocellar dot brown. Second orbital one-fourth other two. Vibrissæ long, other oral bristles short. Proboscis prominent and projecting forward; carina short, low, narrow and confined to upper part of face. Face dull yellow. Width of

cheeks about one-sixth greatest diameter of eyes. Cheeks yellow, a brown spot on each side, just above and behind vibrissa. Eyes with yellow pile.

Six acrostichal rows; no prescutellars. Dorsum of thorax dull reddish yellow, with a pair of darker indistinct longitudinal stripes and dark areas on and behind the humeri. Scutellum reddish yellow. Pleuræ pale yellow, a reddish line running forward from base of wing; darker above this line. Legs pale yellow. Preapical bristles only on third tibiæ, apicals only on second.

Abdomen dull reddish yellow, with posterior black bands on first four segments.

Wings clear. Costal index about 1.9; 4th vein index about 2.0; 5x index about 1.8; 4c index about 1.4.

Length body 2mm., wings 2mm.

Type and ten paratypes, Adjuntas, P. R., June 8-13, 1915 (Lutz and Mutchler). Two specimens, San Francisco Mts., San Domingo, (Busck). The females agree with the above description. Some specimens are a little smaller and have the dark marks on front, thorax and abdomen practically invisible. There are intermediate specimens, and I suppose that the difference is due to age.

The species is distinct from other described species in the color of the thorax. Its most unusual peculiarity is the fewness of the apical and preapical bristles, in which it resembles *D. quadrata* n. sp. The large hairy third antennal joint is also noteworthy.

Drosophila quadrata, n. sp.

♂. Arista with six branches above and three below. Antennæ brown. Front one-half width of head, wider above; pale yellow. Second orbital not distinguishable from neighboring hairs. One large vibrissa, other oral bristles reduced practically to hairs. Carina low and narrow, face broad and excavated on each side of it; face yellow. Proboscis yellow, palpi dark brown. Cheeks yellow, their greatest width about one-fifth greatest diameter of eyes. Eyes with yellow pile.

Eight rows of acrostichal hairs; no prescutellars; the anterior dorsocentral bristles are only a little behind the suture. Dorsum of thorax, scutellum, pleuræ and legs dull brownish yellow. There is a dark brown stripe on the pleura extending as a straight band from just under the haltere almost to the neck. Below this stripe the pleura is paler. Apical bristles only on the second tibiæ, preapicals only on the third.

Abdomen yellow, each segment with a dark brown posterior margin.

Wings clear; costal index about 1.0; 4th vein index about 5.5; 5x index about 6.0; 4c index about 5.0.

Length body 1¾mm., wings 2mm.

Type and three paratypes, Kushla, Alabama, April, 1915. Also one specimen, Tifton, Ga., October, 1896. (Coll. A. L. Melander).

This species is most like *D. prognatha*, n. sp. which it resembles in its few tibial bristles, in the presence of the pleural stripe, etc. The third joint of the antennæ is here small and dark, while in *D. prognatha* it is large and yellow; and the extraordinary wing vein indices of *D. quadrata* will serve to distinguish it from most other species of the genus.

Drosophila superba, n. sp.

♀. Arista with eight branches above and four below. Antennæ brown, third joint dark. Front about one-third width of head, wider above; yellow. Second orbital scarcely more than a hair. Only one prominent oral bristle. Carina low and narrow, confined to upper part of face. Face yellow. Cheeks yellow, their greatest width scarcely one-sixth greatest diameter of eyes. Eyes sparsely clothed with very short, fine, pale pile.

Acrostichal hairs is about ten rows; no prescutellars; a single pair of dorsocentrals. Dorsum of thorax yellow, with two pairs of interrupted brownish longitudinal stripes, the median pair broader than the outer. Scutellum brownish yellow; pleuræ yellow, with two longitudinal dark reddish brown stripes. Legs yellow. Apical and preapical bristles on first and second tibiæ, preapicals on third.

Abdomen dark brown, yellow at base.

Wings brownish black, with four hyaline areas; one at the base; one including the apical part of the costal cell and extending to the anal cell; a band extending directly across the wing about its middle, between the two cross veins; a spot reaching from the middle of the first posterior cell to the wing margin in the second posterior cell. Costal index about 3.0; 4th vein index about 1.0; 5x index about 1.0; 4c index about 0.7.

Length body 3mm., wings 3¼mm.

Type, Cacao, Trece Aguas, Alta Vera Paz, Gautemala (Schwarz and Barber). U. S. N. M. collection.

The color of the wings and pleuræ and the single pair of dorsocentrals will serve to distinguish this species.

Drosophila projectans, n. sp.

♂. Arista with five branches above and one below. Antennæ brown. Front one-third width of head, broader above, velvety black, brownish below, with a silvery whitish reflection, small triangle and orbits polished. Second orbital minute. Second oral bristle quite small. Carina high, narrow; face brown. Clypeus prominent. Proboscis and palpi pale yellow. Cheeks yellow, their greatest width about one-sixth the greatest diameter of eyes. Eyes bare.

Dorsum of thorax strongly convex; a single pair of dorso-central bristles and no prescutellars. Acrostichal hairs in six rows. Dorsum of thorax, scutellum, and pleuræ above wings shining blue black. Pleuræ below wings, and legs, pale yellow. Apical bristles on second tibiæ, preapicals on third.

Abdomen shining black. First segment with one median and two small lateral yellow spots; second segment with a median one, third with an anterior yellow band.

Wings black just beyond the base, a black oblique band from the apex of the costal cell to the apex of the anal cell, tip of second vein darkened. The apical portion of the costal cell is drawn out into a rounded process, extending beyond the rest of the anterior margin of the wing. Costal index about 1.1; 4th vein index about 2.2; 5x index about 2.0; 4c index about 1.9.

Length body 1½mm., wings 1½mm.

Type, San Francisco Mts., St. Domingo, 4. 9. 05, (A. Busck) U. S. N. M. collection. A headless specimen from Montserrat, Trinidad, W. I. (A. Busck) agrees.

This species belongs to the same group as *D. dimidiata* Lw. and *D. thoracis* Willist. The projecting costal cell, low costal index and spotted wings will serve to distinguish it from those species.

A REVIEW OF THE AMERICAN SPECIES OF XYLOCELIA.

(Hymenoptera; Psenidae.)

By CLARENCE E. MICKEL, Lincoln, Nebraska.

The genus *Xylocelia* has received comparatively little attention from systematists so far as the American species are concerned. Dr. A. S. Packard recognized the genus as represented in our fauna in 1867 under the name *Diodontus* of authors (nec Curtis), and placed in it the new species *americanus*. In 1892 Mr. W. J. Fox described five new species and gave a synoptic key for the six species then known. Since 1892 a number of new species have been described by Messrs. Cockerell and Fox, Mr. H. L. Viereck, Mr. S. A. Rohwer and Dr. E. G. Titus. While working over the material in the collection of the University of Nebraska recently, seven new forms were noted by the writer. With this addition the list of known American forms of *Xylocelia* totals twenty-five and it seems desirable to present at this time a synoptic key for separating the species. In cases where examples of a species have not been at hand, the characters used in the table are based on the original descriptions. No doubt more careful collecting of our smaller wasps will bring other new forms to light, and it is hoped that this review may be of service in determining the described American species. The types of the seven new species here described are in the entomological collection of the University of Nebraska. The writer wishes to acknowledge his indebtedness to Dr. E. G. Titus for the loan of the type of *Xylocelia adamsi*, and to Prof. Myron H. Swenk for going over the manuscript.

Genus *Xylocelia* Rohwer.

1837. *Diodontus*, Shuckard, Essay indig. Fossor. Hymen., p. 186, (nec Curtis).
1867. *Diodontus*, Packard, Proc. Ent. Soc. Phila., vi, p. 392.
1892. *Diodontus*, Fox, Trans. Amer. Ent. Soc., xix, p. 314.
1915. *Xylocelia*, Rohwer, Proc. U. S. Nat. Mus., xxxxix, p. 243.

SYNOPSIS OF THE SPECIES.

FEMALES.

1. Mandibles yellowish or whitish.....4
   Mandibles entirely black.....2
2. Mesoscutum with the punctures sparse and indistinct on the posterior half; anterior half of front striato-punctate, the striæ becoming more or less obsolete on the posterior half..... *ater.*
   Mesoscutum with punctures distinct and rather close throughout; front with strong separated punctures.....3
3. All the tibiæ and tarsi reddish brown, more or less testaceous beneath; nervures of anterior wings yellowish testaceous..... *adamsi*
   All the tibiæ and tarsi black; nervures of anterior wings black..... *nigritus*
4. Posterior lobes of pronotum yellowish.....8
   Posterior lobes of pronotum entirely black.....5
5. Posterior face of propodeum with a median, moderately deep, wedge-shaped fovea, the remainder of the posterior face finely, irregularly rugose.....6
   Posterior face of propodeum without any wedge-shaped fovea, the entire surface coarsely reticulate.....7
6. Apical antennal joint with a strong longitudinal furrow beneath; all the tibiæ testaceous; emargination of labrum broad and deep..... *antennatus*
   Apical joint of antennæ not furrowed beneath, simple; all the tarsi more or less blackish; emargination of labrum narrow, moderately deep. *melathoracicus*
7. Legs entirely black; head smooth, shining, sparsely punctate..... *americanus*
   Legs more or less testaceous; head not smooth, distinctly punctate; palpi light testaceous; labrum broadly and shallowly emarginate..*spiniferus*
8. All the tibiæ yellowish or orange red, not black.....9
   Middle and hind tibiæ more or less blackish; wing nervures blackish.....10
9. Abdomen shining, with very close, fine punctures; nervures of wings testaceous..... *occidentalis*
   Abdomen shining, impunctate; nervures of wings black..... *florissantensis*
10. Front rather densely punctate; abdomen distinctly petiolate..... *gillettei*
    Front sparsely but distinctly punctate; abdomen not distinctly petiolate, subsessile.....11
11. Postero-lateral angles of propodeum strongly produced; posterior face of propodeum finely, sparsely rugose, with a rather deep, median, wedge-shaped fovea..... *striatus*
    Postero-lateral angles of propodeum not strongly produced; posterior face of propodeum rather coarsely reticulate..... *siouxensis*

MALES.

1. Mandibles yellowish or whitish.....7
   Mandibles entirely black.....2
2. Posterior lobes of pronotum black.....3
   Posterior lobes of pronotum yellowish; antennal joints 8-12 serrate beneath..... *maestus*
3. Antennal joints not spined beneath.....4
   Antennal joints 9 or 10-12 slightly spined beneath.....5
4. Abdomen microscopically punctate, appearing impunctate..... *flavitarsus*
   Abdomen punctured with strong, distinct, separated punctures..... *cockerelli*
5. Mesoscutellum striated posteriorly; antennal joints 9-12 slightly spined beneath..... *argentinæ*
   Mesoscutellum punctured like the mesoscutum; antennal joints 10-12 slightly spined beneath.....6
6. Cheeks striato-punctate; propodeum indistinctly channeled above..*vallicolæ*
   Cheeks hardly striated; propodeum not channeled above, subsp. *vallicolæ salicis*

7. Posterior lobes of pronotum black.....13
   Posterior lobes of pronotum pale or yellowish.....8
8. Antennal joints 9-12 not serrate beneath.....9
   Antennal joints 9-12 serrate beneath.....10
9. Mesoscutum subopaque, with minute almost adjoining punctures. *brunneicornis*
   Mesoscutum shining, sparsely punctured.....*fraternus*
10. Clypeus produced in the middle, with two large, obtuse teeth.....*bidentatus*
    Clypeus not produced in the middle.....11
11. Front subopaque, very densely punctate, appearing granulose.... *occidentalis*
    Front more or less shining, with separated or sparse punctures.....12
12. Front with distinct, separate punctures; frontal impressed line faint. *neomexicanus*
    Front shining, with a few scattered punctures; frontal impressed line very distinct.....*florissantensis*
13. Front sparsely punctured; lineolate running into tessalate; antennæ simple, not serrate beneath.....*leguminiferus*
    Front densely punctured; antennæ more or less serrate beneath.....14
14. Distance between the posterior ocelli a little greater than the distance between the lateral ocellus and the nearest eye margin, lateral margin of posterior face of propodeum not toothed.....*crassicornis*
    Distance between the posterior ocelli distinctly less than the distance between the lateral ocellus and the nearest eye margin; lateral margin of posterior face of propodeum toothed.....*rugosus*

Xylocelia occidentalis Fox.

1892. *Diodontus occidentalis* Fox, Trans. Amer. Ent. Soc., xix, p. 315.

Type locality: Southern California and Arizona. The University collection contains one female and four males from the following Nebraska localities:

Sowbelly Canyon, Sioux County, June 23, 1911 (R. W. Dawson), 1 ♀; Glen, Sioux County, July 12, 1910 (L. Bruner), 2 ♂; Monroe Canyon, Sioux County, August 16, 1912 (R. W. Dawson), 1 ♂; Monroe Canyon, Sioux County, August 20, 1908 (R. W. Dawson), 1 ♂.

Xylocelia rugosus Fox.

1892. *Diodontus rugosus* Fox, Trans. Amer. Ent. Soc., xix, p. 315.

Type locality: Montana, Illinois. Two specimens at hand from Omaha; July 2, 1913 (L. T. Williams), ♂ and August 1, 1914 (L. T. Williams), ♂.

Xylocelia brunneicornis Viereck.

1906. *Diodontus brunneicornis* Viereck, Trans. Amer. Ent. Soc., xxxii, p. 212.

Type locality: Sedgwick County, Kansas.

Xylocelia florissantensis Rohwer.

1909. *Diodontus florissantensis* Rohwer, Trans. Amer. Ent. Soc., xxv, p. 107.

Type locality: Florissant, Colorado.

Xylocelia crassicornis Viereck.

1904. *Diodontus crassicornis* Viereck, Trans. Amer. Ent. Soc., xxx p. 243.

Type locality: Corvallis, Oregon.

Xylocelia fraternus Rohwer.

1909. *Diodontus fraternus* Rohwer, Trans. Amer. Ent. Soc., xxxv, p. 106.

Type locality: Florissant, Colorado.

Xylocelia flavitarsus Fox.

1892. *Diodontus flavitarsus* Fox, Trans. Amer. Ent. Soc., xix, p. 316.

Type locality: Colorado.

Xylocelia leguminiferus Cockerell and Fox.

1897. *Diodontus leguminiferus* Cockerell and Fox. Proc. Acad. Nat. Sci. Phila., p. 141.

Type locality: Santc Fe, New Mexico.

Xylocelia neomexicanus Rohwer.

1909. *Diodontus neomexicanus* Rohwer, Trans. Amer. Ent. Soc., xxxv, p. 106.

Type locality: Rowe, New Mexico.

Xylocelia maestus n. sp.

♂. Length 5.5mm. Labrum not exposed; front strongly ruguso-punctate; vertex and occiput finely granulate with distinct punctures; genæ with close elongate punctures which give them the appearance of being striato-punctate; impressed line of front wanting; antennal joints 8-12 serrate beneath; antennæ puberulent, joints 1 and 2 of flagellum equal; mesoscutum strongly punctured, densely so anteriorly; mesoscutellum with fine, well separated punctures; episterna anteriorly very coarsely reticulate, posteriorly finely so, tending to become obliquely rugose; propodeum above coarsely reticulate, posterior face with larger reticulations, supra-medially there is a large triangular fovea, much larger than the others on the posterior surface; abdomen distinctly microscopically punctate, the punctures becoming larger on the apical segments; lower portion of front, and clypeus silvery pubescent. Wings hyaline, stigma and nervures of anterior wings piceous. Black; posterior lobes of pronotum yellowish; palpi, tegulæ, all the tibiæ in front, anterior tarsi, and basal half of middle tarsi, testaceous.

♀. Unknown.

Type: A male collected at Omaha, Nebraska, August 29, 1914 (L. T. Williams).

One paratype collected at the same time and place. Most nearly related to *flavitarsus*, from which it differs in having the antennæ serrate beneath, the posterior lobes of the pronotum yellowish, and other minor characters.

Xylocelia argentinæ Rohwer.

1909. *Diodontus argentinæ* Rohwer, Trans. Amer. Ent. Soc., xxxv, p. 104.

Type locality: Cripple Creek, Colorado.

Xylocelia vallicolæ Rohwer.

1909. *Diodontus vallicolæ* Rohwer, Trans. Amer. Ent. Soc., xxxv, p. 104.

Type locality: Florissant, Colorado.

Xylocelia vallicolæ salicis Rohwer.

1909. *Diodontus vallicolæ salicis* Rohwer, Trans. Amer. Ent. Soc., xxxv, p. 105.

Type locality: Boulder, Colorado.

Xylocelia americanus Packard.

1867. *Diodontus americanus* Packard, Proc. Ent. Soc. Phila. vi, p. 393.

Type locality: Brunswick, Maine.

Xylocelia spiniferus n. sp.

♀. Length 4.5-5mm. Labrum broadly and very shallowly emarginate; front finely granulate with distinct punctures; vertex more closely punctured, cheeks sparsely punctured; antennæ puberulent, first joint of flagellum slightly longer than the second; mesoscutum with fine, distinct punctures, the punctures quite dense anteriorly; mesoscutellum shining, microscopically punctate; episterna coarsely reticulate, obliquely rugose posteriorly; propodeum coarsely reticulate above, more openly so on the posterior face; sides of propodeum coarsely rugose; the lateral margins of the propodeum produced, forming a short, blunt spine; abdomen apparently impunctate; wings hyaline; stigma and nervures of anterior wings piceous. Black; mandibles yellowish (except reddish at tips); palpi, tegulæ, anterior tibiæ and tarsi, intermediate tibiæ in front, intermediate tarsi basally, apex of posterior femora and base of posterior tarsi, all light testaceous.

♂. Unknown.

Type: A female collected at Omaha, Nebraska, June 12, 1914 (L. T. Williams); paratypes as follows: Omaha, June 12, 1914 (L. T. Williams), 2 ♀; Omaha, July 19, 1914 (L. T. Williams), 1 ♀; Omaha, July 20, 1914 (L. T. Williams), 2 ♀.

Apparently related to *americanus* from which it differs in having the legs more or less testaceous, the front distinctly and fairly closely punctate, and the tarsal joints not unusually spinose.

Xylocelia antennatus n. sp.

♀. Length 4.5mm. Labrum deeply and roundly emarginate; front finely granulate, distinctly punctate; vertex and occiput similarly sculptured; cheeks sparsely punctate; antennæ short, slightly longer

than the head; the last joint with a longitudinal furrow beneath; mesoscutum distinctly punctate, densely so anteriorly; mesoscutellum with small, shallow punctures, slightly impressed medially, episterna anteriorly, quite coarsely reticulate, posteriorly finely rugose; upper portion of the propodeum finely reticulate, grading off into a finely rugose sculpture on the posterior face and the sides; posterior face of propodeum with a median, wedge-shaped, fairly deep fovea; abdomen with fine, well separated punctures; the four apical segments somewhat pubescent; wings hyaline; stigma and nervures of the anterior wings blackish. Black; mandibles yellowish (except the tips reddish); tegulæ and the tibiæ testaceous.

♂. Unknown.

Type: A female collected at Omaha, Nebraska, July 15, 1914 (L. T. Williams).

This species and the following one differ from the other American species of this genus in the fine sculpture of the posterior face of the propodeum and the episterna. They are probably most closely related to *americanus*, from which this species differs most obviously in the above characters and by the furrow of the apical antennal joint beneath.

Xylocelia metathoracicus n. sp.

♀. Length 4.5-5mm. Labrum narrowly and deeply emarginate; front microscopically granulate, with distinct well-separated punctures; frontal impressed line distinct; vertex, occiput and cheeks sculptured like the front; antennæ short, slightly longer than the head, puberulent; first joint of flagellum slightly longer than the second; mesoscutum shining, densely punctate anteriorly, the punctures sparser posteriorly; mesoscutellum slightly impressed medially, rather sparsely punctate; episterna anteriorly somewhat roughly sculptured, slightly reticulate and strongly, deeply punctate, the sculpture tending to become finely rugose posteriorly, upper surface of the propodeum finely reticulate, the posterior face finely rugose, provided with a small, median, wedge-shaped fovea; sides of the propodeum finely granulate; abdomen microscopically, but distinctly punctate; pygidium narrow, about twice as long as broad, rounded at the apex, uniformly punctured; wings hyaline, nervures of anterior wings dark testaceous, stigma black. Black; mandibles except the tips yellowish; tegulæ and anterior tibiæ in front testaceous.

♂. Unknown.

Type: A female taken at Omaha, Nebraska, July 2, 1913 (L. T. Williams). Related to *antennatus*. Differs in having the apical joint of the antennæ simple, the sides of the propodeum more delicately sculptured and only the anterior tibiæ in front testaceous.

Xylocelia gillettei Fox.

1892. *Diodontus gillettei* Fox, Trans. Amer. Ent. Soc., xix, p. 316.

Type locality: Fort Collins, Colorado. One female specimen in the University collection from Harrison, Nebraska, August 20, 1912 (R. W. Dawson).

Xylocelia striatus n. sp.

♀. Length 6-6.5mm. Labrum not exposed; front very finely granulate, sparsely punctate; impressed line of front wanting; antennæ distinctly longer than the head, slightly puberulent; first joint of flagellum distinctly longer than the second; mesoscutum shining, densely punctate anteriorly, very sparsely punctate posteriorly; mesoscutellum shining, with a very few shallow punctures; episterna coarsely, transversely rugose; upper surface of propodeum with a fairly distinct, reticulate inclosed space, laterally with the upper surface obliquely rugose; the posterior face finely rugose, with a median, wedge-shaped fovea; sides of the propodeum sparsely, obliquely striate, the postero-lateral angles produced, forming a blunt spine; abdomen finely, distinctly punctate; wings hyaline; stigma and nervures of anterior wings piceous. Black; mandibles except the tips, the posterior lobes of the pronotum yellowish; tegulæ and anterior tibiæ in front yellowish testaceous. Form robust.

♂. Unknown.

Type: A female collected at Dickinson, North Dakota, July 4, 1914 (O. A. Stevens); one paratype collected at Laramie, Wyoming. May easily be distinguished by the coarse sculpture of the episterna, the characteristic sculpture of the posterior face of the propodeum, the presence of blunt lateral spines on the propodeum and the robust form.

Xylocelia siouxensis n. sp.

♀. Length, 5mm. Labrum not exposed; front finely granulate, sparsely punctate; impressed line of front distinct; vertex, occiput and cheeks sculptured like the front; antennæ distinctly longer than the head, slightly puberulent; first joint of flagellum distinctly longer than the second; mesoscutum shining, densely punctate anteriorly, very sparsely punctate on the posterior half; mesoscutellum shining very sparsely punctate; episterna above coarsely reticulate anteriorly, below and posteriorly, finely, transversely rugose; propodeum above finely reticulate, the posterior face more shining, with quite large, shallow foveæ, supra-medially there is a small, somewhat depressed, triangular area; sides of the propodeum rather shining, with four or five coarse, oblique striæ; abdomen microscopically punctate; pygidium about one and one-fourth times as long as wide; strongly punctate; wings hyaline, stigma and nervures of anterior wings piceous. Black;

mandibles, except the tips and posterior lobes of the pronotum yellowish; tegulæ and anterior tibiæ in front testaceous.

♂. Unknown.

Type: A female collected in Monroe Canyon, Sioux County, Nebraska, August 19, 1912 (R. W. Dawson). Related to *striatus*, but is smaller, more slender, has the propodeum sculptured differently and the postero-lateral angles of the propodeum not produced.

Xylocelia nigritus Fox.

1892. *Diodontus nigritus* Fox, Trans. Amer. Ent. Soc., xix, p. 317.

Type locality: Colorado.

Xylocelia adamsi Titus.

1908. *Diodontus adamsi* Titus, Ecology of Isle Royale, Michigan Survey, p. 319.

The following description is drawn from the type specimen kindly loaned the writer by Dr. E. G. Titus.

♀. Length 7.1mm. Labrum deeply and angulately emarginate, the teeth formed by the emargination acute; front with strong, rather close punctures, finely granulate between the punctures; median impressed line of front faint; vertex, occiput and cheeks punctured like the front; (antennæ missing in the type); mesoscutum with strong, rather close punctures, denser on the anterior and posterior margins; suture between the mesoscutum and mesoscutellum foveolate; mesoscutellum distinctly punctured; episterna coarsely reticulate anteriorly, obliquely rugose posteriorly; upper surface of propodeum coarsely reticulate; posterior face of propodeum coarsely reticulate, supramedially with a large, pentagonal enclosed area; sides of propodeum with a few, coarse rugæ; abdomen microscopically punctate; pygidium triangular, about one and one-fourth times as long as wide, strongly punctured on the basal half; wings hyaline, stigma black, nervures yellowish testaceous. Black; tegulæ brown, yellowish anteriorly; all the tibiæ and tarsi reddish brown, more or less testaceous beneath.

♂. Unknown.

Type: A female collected at Isle Royale, Michigan (Adams). Related to *nigritus*, but the sculpture of the propodeum, coloration of anterior wing veins, and of the tibiæ and tarsi, are different.

Xylocelia ater n. sp.

♀. Length 6-7mm. Labrum large, deeply and angulately emarginate; lower portion of front tending to be striato-punctate; upper portion of front fairly closely and shallowly punctate; median impressed line

of front very faint; vertex, occiput and cheeks punctured like the front; mesoscutum shining, densely punctured anteriorly, the punctures fine and sparse on the posterior half; mesoscutellum finely and rather closely punctured; episterna coarsely reticulate anteriorly, coarsely obliquely rugose posteriorly; upper surface of propodeum coarsely reticulate; posterior face of propodeum coarsely reticulate, with a large, supra-medial, triangular fovea; sides of propodeum very coarsely obliquely rugose; abdomen rather closely, microscopically punctate; pygidium triangular, about one and one-half times as long as wide, strongly punctured; wings hyaline; stigma and nervures of anterior wings piceous. Entirely black.

♂. Unknown.

Type: A female collected at Omaha, Nebraska, July 27, 1914 (L. T. Williams). Four paratypes as follows: Omaha, June 20, 1914 (L. T. Williams), 1 ♀; Omaha, July 1, 1913 (L. T. Williams), 1 ♀; Omaha, August 29, 1914 (L. T. Williams), 1 ♀; one female specimen without data.

Related to *nigritus*, but differs in the differently sculptured front and propodeum, and the mesoscutum not strongly punctured before the mesoscutellum.

Xylocelia cockerelli Rohwer.

1909. *Diodontus cockerelli* Rohwer, Trans. Amer. Ent. Soc., xxxv, p. 105.

Type locality: Florissant, Colorado.

Xylocelia bidentatus Rohwer.

1911. *Diodontus bidentatus* Rohwer, Proc. U. S. Nat. Mus., xxxx, p. 560.

Type locality: Nerepsis, New Brunswick. This species cannot be the male of *Xylocelia adamsi*, as has been suggested by Rohwer, because of the different structure of the clypeus.

AQUATIC HEMIPTERA. A STUDY IN THE RELATION OF STRUCTURE TO ENVIRONMENT.

By J. R. DE LA TORRE-BUENO, White Plains, N. Y.

Water is everywhere. Wherever there is water, there are to be found Aquatic Hemiptera. From the woodland spring deep in the cool and dusky shadows to the tropic ocean steaming in the flaming rays of the noonday sun, these daring insect navigators adventure themselves on the bosom of the waters, to them as vast as, even vaster than the mighty seas were to the bold mariners of old. Protean in form, variable in size—some less than the head of a pin, others of monster size for insects, for they attain the length of half a foot—these fierce pirates range the waters, seeking prey. Not even the wide-spread and multiform water beetles exhibit such a wide diversity of form, structure and habitat.

The old-time divisions of *Cryptocerata* and *Gymnocerata Littoralia* separate these two Hemipterous groups on the obvious character of the absence or presence of visible, free antennæ, and very fairly divide the dwellers in the waters from those that live upon them or on their shores. And in this antennal diversity we have indeed a character arising strictly from the conditioning environment. Obviously, long antennæ, while of the utmost use to the above-water forms, would be distinctly in the way in deep-swimming insects, so in the Order *Sandaliorrhyncha*, containing the family *Corixidæ*, and in the Heteropterous families *Notonectidæ*, *Naucoridæ*, *Belostomatidæ* and *Nepidæ*, the antennæ are three or four-jointed, concealed in foveæ under the head, the joints being sometimes palmately explanate, as in *Lethocerus;* sometimes stout and simple, with fringing hairs, as in *Notonecta*. But the nymphal development of *Belostoma* and *Ranatra*, for example, points to the simple, stout, three- or four-jointed antenna as the primitive form, since in the early stages of these bugs they are simple and do not begin to show the explanations until the third or fourth instar.

The wings in these groups are misleading phylogenetically, since the venation seemingly is very simple in some instances, and actually so in others. Of course, a sub-aquatic life must profoundly modify the organs of flight if they are unused, so in *Plea* the specialization reaches such a degree that the second pair of wings is absent and the first pair is completely coriaceous and hardened and soldered together, which, in passing, is also the case in the genera *Nerthra* of North America and *Peltopterus* of Africa, in the *Gelastocoridæ*, which are forms living on the banks of streams and bodies of water; and in the *Aphelocheirinæ* of the Old World, certain dimorphic species exhibit wingless forms. In *Ranatra* the cross veins of the second pair of wings are reduced to mere spurs arising from the longitudinal veins, and in the first pair are entirely absent. In *Anisops* and *Buenoa*, *Enithares* and *Nychia*, the entire hemelytra (also called tegmina) are hyaline and with nothing but a few nearly obsolete longitudinal veins, and in the last named, the second pair of wings is absent. All the *Belostomatidæ* are strong fliers, and here, as may be imagined, the wings are large and powerful, the venation of the upper and lower pairs complete, except that in some forms, the membrane of the tegmina is nearly obsolete. The *Naucoridæ* also have unspecialized wings and the *Corixidæ* as well, in the majority of cases. To anyone at all familiar with these groups at first hand, the absurdity of calling them primitive is self-evident. From what has been said, it can readily be seen that the wings in the aquatic forms are unreliable and misleading as criteria of position in the phylogenetic scale. Where they have continued to be of use, the wings persist in a fairly non-complex form; where disuse has ruled, they have been modified and even have become obsolete to the extent of disappearing.

The most profound changes, as might be supposed, have taken place in the respiratory apparatus, which has become adapted in the most remarkable ways to aquatic life; and in the legs which have been transformed to cope with the medium in which the insects move. There are three main forms of respiratory apparatus among the water-dwellers, which may be called the *dorsal reservoir and pile*, the *anal tube*, and the *abdominal channel types*. The tracheal systems as such are practically identical in all three forms of air supply. The *Corixida*, *Belostomatidæ* and *Naucoridæ* have the dorsal reser-

voir; the *Notonectidæ* the abdominal channel; and the *Nepidæ* the tube type. In the forms with pile and a dorsal reservoir, practically the entire abdomen is pilose and the dorsum more or less concave, forming a reservoir under the convex wings, which is ordinarily filled with air. This air is renewed by absorption from the atmosphere direct and also by reoxygenation from the contained air in the water. In the *Corixidæ*, the abdomen also can be seen covered with a silvery coating of air imprisoned in the pile. The insects of this last group, as a general rule, remain at the bottom, holding fast to pebbles, grains of sand, and other inequalities affording a hold, and from time to time may be seen to pass the third pair of legs through the air coating. Now and again they swiftly ascend, impinge upon the surface-film and dart back to the bottom. The air they carry makes it unnecessary for them to exert themselves to go up, but their descent, while quick, is laborious, and it is this extreme lightness that compels them to anchor themselves, so to speak, in order to remain at the bottom. The *Naucoridæ* haunt the aquatic vegetation among which they creep, and to renovate their stored air, they come to the surface, where the tip of the abdomen breaks through the surface film and the air they carry is purified by diffusion or perhaps by being expelled by body movements, fresh air being then drawn in to replace it. In this family, or group, as in the *Belostomatidæ*, the dorsal part of the abdomen is hollowed out, but only slightly, and is covered with a heavy pile, which affords storage for much air and makes it unnecessary for the bug to come to the surface with any degree of frequency to purify this stored air, which to some degree must be done also by absorption of the oxygen given off by the aquatic vegetation it haunts. In the *Belostomatidæ*, however, there are two more or less retractile strap-like appendages, the lengthened peritreme of the sixth abdominal spiracles, which are moved from the connexivum and open dorsally at a slit in the abdomen, which on the underside is covered in both sexes by the genital plate. These strap-like appendages have been employed as specific characters, based on their comparative lengths, but as they are, as already stated, more or less retractile, individuals of the same species, *L. americanus* for instance, will have them of different lengths. They have also been considered to be a part of the genital apparatus and perhaps to be ovipositors, but a simple dissection

suffices to show anyone who will take the pains to make it, that they are strictly respiratory appendages, which may be readily observed in operation in aquaria. These appendages break through the surface film and the hollowed sides being placed in juxtaposition, they form a tube leading air to the spiracles, as already mentioned. These spiracles are larger than the others, and from them lead the two main tracheal tubes lengthways of the body, which connect by side branches with each other and with the functional abdominal spiracles. These spiracles are placed in a pilose stripe, silvery with enmeshed air when the bug is in water, situated on the under side of the abdomen at the connexivum. The thoracic spiracles are also large and functional, but from their structure, size and position are evidently used for respiration only when the bug is in flight. The nymphal respiratory adaptation is quite different, as the strap-like appendages are absent, the abdomen is totally covered with a long and thick pile, and there are two large spiracles situated under the sternal plates, which are very large and fringed with long hairs.

The typical, and only, representatives of the anal tube type of aquatic respiration are the *Nepidæ*. This family is extremely peculiar, and its aquatic life offers no criterion to its phylogenetic position. Based on certain structural characters, it has been removed from the Pagiopod Heteroptera to the Trochalopod series by Schjödte, followed by Kirkaldy. This has not been accepted by the European master, O. M. Reuter, but the manner of oviposition, and therefore, the genital characteristics, have been overlooked. These, if at all valid as indications of affinity, confirm the propriety of its removal to the vicinity of the *Reduviidæ*, to certain of which it has indeed a striking superficial resemblance in structure, which is borne out by the appendages of the ovum and by the egg-laying habits, a parallel to which is to be found in *Melanolestes abdominalis*. This predaceous Reduviid, not unfrequently found under stones in fields, inserts its eggs into the earth, leaving at the surface a crown of filaments, which are greater in number but similar in appearance to the seven filaments surmounting the ovum of *Nepa*. For this reason, it seems best to continue to consider this family as properly placed in the Trochalopoda and near to the *Reduviidæ*, as has been done by Kirkaldy.

Reverting now to the respiratory tube in this family of water-bugs, this, as is well-known, consists of two parts fringed with hairs, and grooved in the inner surface, forming thus two half tubes longitudinally divided. When the insect is submerged these two half tubes are kept together by the pressure of the water, the hairs serving to prevent leakage of air at the junction or seam between the two halves of the tube. These two halves are nothing but the lengthened peritreme of the seventh pair of abdominal spiracles, and they vary in length with the genus and species and even with the individual. It has been experimentally demonstrated that the shortening of the tube in any individual in no wise interferes with its respiration. But what does not appear to be so well known, if known at all, is that the halves may be of unequal length without at all affecting the usefulness of the tube. I have observed this in a specimen of *Ranatra* thus maimed, which was kept alive in an aquarium for a considerable period and which suffered no inconvenience from the inequality of the halves of the air tube. As the bug hangs head down from the water plants, the apex of the tube pierces the surface film and leads air in to the round spiracles situated at the base of each filament, from which arise the two main longitudinal tracheal trunks. In *Nepa*, the tube is short, as it is in *Cercotmetus*, a near relative to *Ranatra*, and in *Curicta*, the form that bridges the gap between *Ranatra* and its allies and the *Nepa*-like forms; on the other hand, in *Ranatra* it is long (with perhaps one or two exceptions), as well as in *Laccotrephes* and other exotic genera. Here is a distinct adaptation to a preferred habitat, as *Ranatra* and the other long-tubed genera are deep-water dwellers, while *Nepa* and its short-tubed congeners is to be found in shallows among grasses. In the *Nepidæ* as a whole there is a most peculiar respiratory structure—the so-called false spiracles, which are six in number and are situated in the connexivum at the third, fourth and fifth abdominal segments. These false spiracles are large and oval in outline, and quite visible to the naked eye. Under the magnifier they are seen to consist of an opaque plate set in a raised margin and provided with round perforations which, in turn, are occluded by a diaphanous membrane. The true spiracles in these segments of the abdomen, as well as in the second segment, are nonfunctional, the former being set in the widened peritreme of these colander-like openings. No experimental

evidence is yet at hand to definitely indicate the purpose of these peculiar structures, but in view of the absence of storage reservoirs for air and of the bug's proneness to submerge itself for long periods of time, it is not unreasonable to surmise that dissolved air is extracted from the water, thus aerating the body fluids as they flow by within the body cavity. The other functional spiracles are the thoracic, which are large and well-developed and apparently used when the insect is in flight, as they are exposed by bending the thorax forward when *Ranatra*, for instance, takes to the air. In the nymph, the respiratory device is superficially the same as in the adult, but is actually quite different. Here all the abdominal spiracles are functional and air is led to them by a very short tube. This is formed by the folding over of the produced last abdominal segment, the amplified connexivum of the others being bent over to form a channel over the spiracles, which are thus in direct contact with air. The internal organization of the respiratory system in nymphs has not as yet been investigated.

The third type of respiratory devices, that is, the abdominal channel, has been but little studied. It is, however, extremely simple. The abdomen is keeled down the middle and from this keel spring outwardly toward the sides of the body elastic and fairly stiff and close-growing long hairs, which meet similar hairs arising from the connexivum edge. There is thus formed a channel on each side of the abdomen which is filled with air and in which the spiracles are placed. The bugs hang in the water abdomen up with its extremity just piercing the surface film. In most species there are three tufts of hair which spread out on the surface leaving an open, water-free spot in the middle which is the point where the connection is made between the abdominal reservoirs and the atmosphere. When totally submerged, the opening closes in some way not well explained so far, although the writer believes that the three tufts mentioned lap over and in some manner serve to obstruct the entrance of water into the channels. In any case, these channels act as storage reservoirs while the insect is in its element. The hairs are not set so near together as to touch, but they are sufficiently close to form an aqueous film at a tension between them which acts to retain the air in the chambers and at the same time to keep water out. This is very necessary in many species, as they only come to the surface to renovate their

air supply, remaining at some distance below the surface the greater part of the time. Very little seems to be known in regard to their internal respiratory system. It might seem, though, that it should be simple. The nymphs are not different from the adults in this adaptation.

All these devices, as can be readily understood, are nicely correlated to the varying conditions under which the groups live. The forms with the pile and reservoir type are deep-water dwellers, the *Corixidæ* clinging to the bottom, the *Belostomatidæ* hiding among the rubbish and mud, the *Naucoridæ*, in a general way, living in the subaquatic vegetation. All comparatively seldom come to the surface; all, therefore, need some means of obtaining air while under water, which will provide a way for its constant automatic renovation independent of direct contact with the atmosphere except at comparatively long intervals. And here we have it. The air and oxygen contained in the water in some way seem to purify the air enmeshed in the pile by contact or by solution and absorption of its contained impurities. In the *Nepidæ*, the difficulty to respiration arising from long submergence is obviated by the so-called false spiracles which, in my view, act as gills and directly aerate the body fluids, which is another most striking adaptation to a special environment. The *Notonectidæ* have no remarkable peculiarity in this respect, as all come to the surface at comparatively short intervals.

In all the aquatic and semi-aquatic forms, predatory habit is the rule, and accordingly the front pair of legs is modified into powerful prehensile organs, excepting only the *Corixidæ*, of which more later. The other two pairs of legs are adapted in the purely aquatic section, in a greater or less degree to swimming, some being highly specialized and others scarcely so. In the majority of the *Belostomatidæ*, the hind pair of legs is broadened to a very marked degree, especially the tibiæ, which are heavily fringed with long hairs. These are exclusively used in locomotion under water. *Lethocerus americanus*, for instance, when hard pressed and with a free field, stretches out its raptorial front legs before it, and gives long strong propulsive strokes with the other two pairs moved synchronously. This is true also of our other native forms of the family, although, since the middle legs are neither so broad nor so powerful, the brunt of the labor is borne by the hind pair in

all. When not pressed, they paddle slowly, alternating the middle and hind legs. In some of the exotic genera (*Sphærodema* and *Limnogeton*), the hind legs are prismatic and sparsely fringed, obviously representing in this respect a less specialized type, and certainly a far less agile one.

In the *Notonectidæ*, the hind pair only is used, and the legs are moved simultaneously. In passing, it may be remarked that this apparently obvious statement is repeated, because in some of the earlier observers, still quoted, it has been said that the legs alternate laterally in swimming. While in this group the legs are not so broad as in the *Belostomatidæ*, the comparatively thicker and longer hair fringe makes them very effective, and the folding back of the hairs on the return stroke tends to facilitate their use and by a species of feathering motion, avoids the retardation of a heavy back stroke. *Plea* is an exception in this family, however, in that its short little legs are narrow and set only with sparse bristles. Naturally, while the little bug swims about, it employs a short, clipping stroke, very different from the free, long, powerful movement of the others. It much prefers to walk, sometimes on the surface film, clinging back down, at others among the water weeds it frequents. The two front pairs of legs in this group are modified into raptorial legs, a rather unusual condition, and they are held closely appressed to the sternum when in repose, but when at the surface and awaiting their prey, they are somewhat outstretched and may be seen as four little eminences on the surface by the observer.

The *Naucoridæ* have legs but little adapted for swimming. They are more or less hairy or bristly, but not flattened like the legs of the Belostomatids. Nevertheless, they contrive to move quite rapidly while swimming, and some indeed, as *Aphelocheirus*, are able to breast rapid streams. On land, however, they walk quite freely for water bugs and especially so if compared with the previously named families, which are very awkward and feeble when moving on land. This difference can be readily understood if it be borne in mind that they live concealed in aquatic vegetation, among which they ordinarily creep. The raptorial front legs are very powerful in this family, the femora being greatly thickened, and the tibiæ strong and curved, terminating in a single sharp tarsal claw.

The simple legs of the *Nepidæ* are narrow, in *Ranatra* and *Amphischizops* much elongate and in *Nepa* and its Old World congeners, shorter and stouter and prismatic, with sparse hairs in all. Naturally, they are poorly adapted to swimming, and the bugs make but awkward and slow progress when in the water. *Ranatra*, for example, alternates the second and third pair of legs when swimming, a slow operation at best. In the first pair, the coxa is very long, the femur is also long, and the tibia closes over it and forms a scissors-like grasping claw.

In the *Corixidæ* also the hind legs only are specialized for swimming. The anterior pair is broadened and flattened of a more or less sickle-like shape and set with stout pegs and hairs in series. These are held by some to be in the nature of a musical organ. At least, some species make a chirping noise, which it is claimed is produced by rubbing this *strigil* as it is called, across the grooved front of the bug's face. The second pair of legs is used in clinging to pebbles and other objects at the bottom.

In the three groups, *Corixidæ*, *Belostomatidæ* and *Notonectidæ*, the legs are nearly as useless for progression on land as the wings are efficient for flying. These members have been totally modified in their adaptation to subaquatic locomotion and the very form of the insects has "suffered a sea-change;" they are smooth, narrow and more or less tapering back and front, especially toward the rear. In some, the smoothness of the exterior is produced by the greater or less polish of the hard parts—thorax, hemelytra—and in others by the possession of a pile which inhibits the natural retardation exercised by water on moving objects through friction, which is overcome by the film of air imprisoned in this pile. This device may be observed in *Notonecta*, especially in the darker forms, in which the hemelytra are to be seen silvered with a thin film of air when the bug is submerged.

Protective mimicry is exhibited mainly in *Ranatra*, which looks like a little brown twig caught in the vegetation. As it is sluggish by nature, it remains in one place and waits for its prey—*Daphnias*, young fish, free swimming aquatic larvæ of one kind or another—which it captures by means of its raptorial scissors-like forelegs as the victims incautiously swim past. The *Belostomatidæ* are more active and pounce

on their prey from ambush, seizing it in their strong front claws and deadening it by injecting their narcotic saliva. They catch fish and in some parts of the world are known as fish-killers. The food of the *Corixidæ* is scarcely known, although Abbott surmises that *Rhamphocorixa acuminata* feeds on an *Ostracod*, which might lead to the conclusion that this family is no exception to the general rule in aquatic Hemiptera. It may also be presumed that they are herbivorous, as they are not fitted with the means to seize living things.

The next to engage our attention are the *Gymnocerata Littoralia*, the surface-dwellers, the water-striders, so-called, comprising the *Gerridæ* and allied families. Here; as might be expected, the environment is more uniform and we therefore find the adaptations less in number and not so unique in character as in the *Cryptocerata*. The antennæ are free, the legs are little changed in the majority, the food is animal, respiration is uncomplicated, and in general the entire structure is simpler.

The universal and most striking adaptation to life upon the waters is the greater or less thickness of the velvety pile that covers the bugs. The object of this is to prevent the insect from getting wet, by enmeshing a film of air which will repel water from its body. On the under side of the body, the pile is more or less silvery in color, while the upper side partakes of the general hue of the species. All the forms—fluviatile, lacustrine, oceanic—have this peculiarity in varying degree.

It is said that some species when closely pursued dive to escape. This submergence has actually been seen in *Rhagovelia*, but not for the purpose of escape. This form, when under water, is covered with a silvery coating of air. Although *Gerris* is said thus to evade pursuit, I have never seen any of our native species try this in spite of all manner of effort and constant attack with a net. At any rate, *Rhagovelia*, in my observation, drowns in a short time and *Gerris* does not long survive submergence.

The only other adaptation is in the structure and function of the legs. In general, in *Gerris*, the first pair is raptorial; the middle pair is used in propulsion and the hind pair as a rudder. Of the non-gerrine forms, the modified land bugs, so to speak, *Hydrometra* walks on the surface, as do *Mesovelia* and the *Hebridæ*, or *Naeogeidæ*. None of these should in any

degree be deemed a true Gerrine, since they clearly belong to widely dissimilar families. In these three last named divisions, all the claws are apical and well-developed, which is also true of certain Oriental Gerrids, save that the claws in the latter are very small. In all the other water-striders, the *Gerridæ* proper, the claws of the last two pairs of feet at least are subapical and inserted in some sort of a slit. The legs in all are heavily pilose, in some few bristly. In the majority they are very slender and long, except in *Microvelia*, *Rhagovelia* and *Rheumatobates*, in which last, in some of the species of the genus, the male femora are apt to be curiously distorted; and in the other two genera much thickened. A description of the process of locomotion in *Gerris remigis*, Say, our common brown water-strider, may be taken as typical of the family *Gerridæ*. The tarsi only of the first pair of legs touch the water for support. The middle pair is used for propulsion by rowing motions, and with them they take longer or shorter strokes, according to their degree of haste, the tarsi only lying flat upon the surface and more or less outstretched. Steering is done by the hind pair mainly, and at times by a longer or shorter stroke from one or the other of the propelling feet to help. Both the tibia and tarsus of the hind pair touch the surface, the legs trailing behind the bug loosely. In the others, the *Halobatinæ*, including the *Rheumatobates* and the other lacustrine and oceanic forms, the process has been observed to be the same in some, and probably is in the others, so far as rowing with the middle feet and steering with the hind goes, but no detailed observations seem to have been made in regard to the use of the anterior feet. Nothing appears to be known in this respect about the oceanic forms. *Microvelia* moves with what Kirkaldy has called a scuttle, that is, a little run in staccato steps, but this is when not in haste. When these tiny bugs are in a hurry, they give long, powerful strokes of the middle legs, and then travel very swiftly. The most peculiar member of the group in regard to adaptation of the organs of locomotion to environment or uses is *Rhagovelia*. This genus, with two exceptions, by preference frequents the swiftest current of streams, where the waters braid in ripples, and is there to be found in schools, sometimes numbering into the thousands, as I saw them in Mexico, on the shallow Rio Santa Catarina, which runs through the City of Monterey, in the North. In these, their favorite

haunts, they swim about with a zigzagging, jerky motion, against the hurrying currents, maintaining their relative positions and even surmounting the stream with little effort. Their ability to cope with a rapid flow is readily appreciated by a consideration of the structure of their legs. The anterior pair are more or less simple, as usual, and so is the posterior. Their function not having been directly observed, it can only be surmised that they do not differ from the other *Veliidæ*. The middle legs, however, are worthy of all attention. In these, the femora are more or less swollen in both sexes, greatly so in the males, not so much in the females. The tibiæ are long and slender, and the tarsi taken together are nearly as long as the tibiæ. These tarsi are highly specialized, and in them lies the secret of *Rhagovelia's* ability to breast strong currents. The last tarsal joint is split for about half its length, and in the split, at its base, is set a plume-like arrangement, which may sometimes be noticed projecting from the tarsus in dried museum specimens. A little mild speculation was excited by this plume, and Champion, in Biologia Centrali Americana, suggested that it might be spread fanwise on the surface of the water. Very fortunately a direct observation of this plume in use happened to be made and it was published, so its function is now well understood. In swimming, the tarsus of *Rhagovelia* lies on the surface along its entire length, with the split perpendicular to the surface. The plume, which is made up of a number of feather-like hairs fastened at one end at the base of the slit and free at the other, is now opened downward into the water, where it spreads fanwise, thus acting in a somewhat similar manner to the web foot of a fowl or the fin of a fish. Of course, this gives the insect a comparatively tremendous purchase and enables it to successfully propel itself against a strong flow.

A few general considerations now suggest themselves. It would seem from the facts set forth that any insects provided with such highly specialized devices fitting them to cope with a complex environment can scarcely be considered primitive forms, not if evolution be operative as is commonly asserted and with simple scientific faith believed to be. Whatever structures are seemingly simple can be explained by the fact of disuse or by non-specialization due to unspecialized use.

As an example, consider the hind wings of *Ranatra*. This insect is obviously highly specialized, but these wings have few if any cross-veins, and these few are mostly spurs arising from the longitudinal veins. Equally obviously, such very narrow wings as this insect has do not require stiffening cross-veins, and in the course of time those that once were there became obsolete. In *Aphelocheirus*, the insect's frequentation of never-drying streams makes even the adventitious use of wings unnecessary for any purpose, and so through ages of disuse they have totally disappeared. Again, how by any stretch of imagination can such a complex organ as the tarsal plume of *Rhagovelia* be considered a primitive structure? In the whole range of insects there is no similar highly specialized swimming device known. No further comment on this phase of the subject seems necessary.

The true position in time of the highly interesting groups of aquatic Hemiptera is to be determined by a careful consideration of the volume of important work that has appeared in Europe and elsewhere on the structure and habits of this series of insect forms, a series which displays so many highly specialized (and therefore *not* primitive) adaptations to a very special environment.

KEY TO THE NEARCTIC SPECIES OF PARACALOCORIS. (HETEROPTERA; MIRIDÆ).

By W. L. McAtee.

The genera *Calocoris* Fieber and *Paracalocoris* Distant are very closely related if indeed they are not identical. They belong to the sub-family Mirinæ and to the tribe Capsini. In these insects the body is not constricted at middle, the cheeks are narrow, hind femora slender, pile of first antennal joint not dilated apically, first joint of tarsus short, last two joints of antennæ distinctly slenderer than second, and the head as seen from side about as long as high at base.

The characters thus far advanced for separating *Paracalocoris* from *Calocoris* are not constant, and the writer must leave to someone having ample material of the latter, the problem of ascertaining whether the two groups really are generically distinct. As used in this paper *Paracalocoris* includes species having the characters above outlined and in addition the following: Pronotum with two discal, subexcavated, velvety black spots, and left clasper of male with a large rounded or pointed lobe on upper side at base. In *Calocoris* as represented by *alpestris* Meyer, *fulvomaculatus* DeGeer, and *norvegicus* Gmelin, the clasper has no such lobe at base, and in the last-named species is much slenderer throughout.

Species that have been referred to *Paracalocoris*, probably erroneously, include two described by Herrich-Schaffer. One of these, *Capsus tetrastigma** has been placed in Resthenia by Stal.† The other, *Capsus externus*,‡ in the writer's opinion, is not a *Paracalocoris*. It is true that the two central velvety black spots on the thorax mentioned in the original description suggest that the insect is a member of this genus, but no *Paracalocoris* has the first antennal joint "as long as head and thorax together," a condition plainly stated in the description and delineated in the illustration of *Capsus externus*. If the

*Die wanzenartigen Insecten. Bd. 9, Nurnberg, 1853, pp. 166-167.

†Hemiptera mexicana enumeravit speciesque novas descripsit. Entomologische Zeitung (Stettin). Jahrgang 23, Nr. 7-9, July-September, 1862, p. 317.

‡Wanz. Ins. 8, 1848, p. 16.

statement regarding the antenna is correct, *C. externus* does not belong to the genus now under consideration. If incorrect and the species really is a *Paracalocoris*, it may be closely related to *P. scrupeus* var. *bidens* n. var., or to *P. limbus* n. sp. From the former, it would be at least varietally distinguished by the four-lobed black marking across posterior part of thorax and from the latter by the scutellum being pale reddish instead of fuscous.

In preparing the key to *Paracalocoris* the writer strove to base it entirely upon fairly constant structural characters and was successful except for the *colon* group. This section is considered to consist of three species, and color pattern is used as a key character. The dangers of the latter course are well illustrated by the several distinct color patterns exhibited by the varieties of *P. scrupeus*, but which nevertheless are practically identical structurally. The writer is convinced that basing classification upon structure, so far as possible is an ideal distinctly worth while. Could it be consistently applied the experience of the student of systematic entomology would be much more satisfactory.

For the loan of material the writer is indebted to Messrs. J. C. Crawford, Otto Heidemann, W. D. Pierce, Wm. T. Davis and H. H. Knight. Mr. Knight kindly gave me for inclusion in this paper descriptions of the new species *hawleyi* and new variety *ancora*, forms upon which he had made economic investigations in New York and which he had already determined as undescribed.

The key includes the following species and varieties:

Species	*Old*	*New*	*Varieties*	*Old*	*New*
10	6	4	26	3	23

With regard to varieties, the writer would remark that placing together in a collection the often very distinct appearing color varieties results in a heterogeneity that inevitably suggests that classification has not been properly done. The use of names for the varieties not only encourages separation of them in collections but facilitates reference to them and is one of the steps necessary to a better understanding of their significance.

KEY TO SPECIES.

A. Hind tibiæ with long hairs standing out all around, obscuring tibial spines .....1. **scrupeus Say.**
AA. Pilosity of hind tibiæ more appressed, especially on inner side; not so abundant and spreading as to obscure spines.
B. First antennal joint as long as, or longer than thorax.
C. Greatest width of thorax over 2 mm., color everywhere except discal spots and membrane a lighter or darker reddish brown..2. **adustus** n. sp.
CC. Greatest width of thorax under 2 mm., coloration not as above, 3. **hawleyi,** H. H. Knight, n. sp.
BB. First antennal joint shorter than thorax.
D. Upper surface polished, very sparsely haired.
E. Second antennal joint considerably less than 2 mm. long. 8. **jurgiosus** Stal.
EE. Second antennal joint considerably more than 2 mm. long. 10. **deleticus** Reuter
DD. Upper surface not polished and with numerous hairs.
F. Second antennal joint 2.4 mm. long or longer.
G. Thorax 2.3 mm. wide.....4. **limbus** n. sp.
GG. Thorax less than 2 mm. wide.....9. **acceptus** n. sp.
FF. Second antennal joint 2.2 mm. long or less.
H. Color yellow-brown to brown, the principal markings consisting of 11 symmetrically arranged pale yellow patches, of which a usually conspicuous and always distinguishable one covers the apical third of scutellum. 7. **multisignatus** Reuter.
HH. Color pattern not as above.
I. Color pattern when fully developed, consisting of pale golden longitudinal vittæ (the longest following cubitus to apex of corium) upon rich mahogany red ground; the insect may be almost wholly pale golden, but the apex of corium never has a distinct dark marking...6. **heidemanni** Reuter.
II. Color pattern not as above; the whole insect may be fusco-stramineous, but the apex of corium (just inside cubitus) always has a distinct fuscous to piceous marking. 5. **colon** Say.

1. **Paracalocoris scrupeus** Say.

C. [apsus] scrupeus Say, * Descriptions of new species of Heteropterous Hemiptera of North America, New Harmony, Indiana, December, 1831, p. 22.† The complete writings of Thomas Say on the entomology of North America, Vol. I, 1859, pp. 342-343. (United States).

This species is distinguished from all the other Nearctic forms by the character of the pilosity of the hind tibiæ. The abundant long hairs on this part of the leg stand out in all directions and almost completely conceal the tibial spines. The presence of spreading hairs on the *inner side* of hind tibia especially is diagnostic, since in other species the pilosity of the

*References are given in full the first time cited and abbreviated thereafter.
†Pagination of this paper according to Banks, N., Catalogue of the Nearctic Hemiptera-Heteroptera, 1910, p. 47.

inner side invariably is appressed. In specimens having the pile of hind tibiæ mostly rubbed off, the presence of a few *outstanding* hairs on *inner* side of tibiæ usually is sufficient indication that the specimen belongs to the *scrupeus* group.

Measurements:* Total length 6–7.5 mm.; width of thorax across front .7–.73 mm., across posterior angles, 1.73–2.3 mm., length of thorax (seen from side) 1.16–1.6 mm.; length of antennal joints; first, 1.6–1.63 mm., second 1.9 – 2.66 mm., third .7–.9 mm., fourth .83–.9 mm.

Range: The specimens examined came from the region marked off by the following states: New York, North Dakota, Texas and Virginia.

Paracalocoris scrupeus divides into numerous color varieties, of which those seen may be separated as follows:

a. Costal margin of hemelytra of about the same color as disc of corium; cuneus sometimes dusky red.
  b. Thorax with dark markings in addition to the discal spots.
    c. Thorax with typical dark markings, that is: portion anterior to discal spots or less piceous or only dusky, and usually piceous dots or more or less dusky clouding near posterior angles.
      d. Corium fusco-piceous.....var. *scrupeus* Say.
      dd. Corium dark red, cuneus a little lighter.....var. *rubidus* n. var.
    cc. Thorax otherwise marked.
      e. Thorax very dark.
        f. Scutellum mostly yellowish or reddish; thorax all dark above except for a median and two lateral areas in line with the discal spots.....var. *triops* n. var.
        ff. Scutellum dark.
          g. Scutellum piceous; thorax with two lateral yellow areas. var. *diops* n. var.
          gg. Scutellum dusky with median light vitta, spots on clavus and corium yellowish red.....var. *delta* n. var.
      ee. Thorax all light, except for indistinct vittæ and dusky maculations from discal spots to posterior margin, and between these and lateral margins; a broad pale vitta traversing scutellum, thorax and top of head; corium yellow brown.....var. *percursus* n. var.
  bb. Thorax without definite dark markings in addition to discal spots.
      h. Corium red-brown with yellow dots.....var. *compar*. n. var.
      hh. Corium except apex, and clavus except base and thin inner margin, uniform orange red; the extreme form of var. *ardens* n. var.

*Intended to show merely the ordinary range of variation.

All measurements were taken with eye-piece micrometer in Zeiss binocular using No. 1 eyepieces and A-2 objectives, which combination yields a magnification of 20. The measurement, length of thorax, is taken with the insect viewed from side and is the direct length from upper front to upper hind margin, disregarding the curvature of dorsum. To have a definite point for beginning, the measurement of first antennal joint is always from constriction above basal knob.

aa. Costal margin of hemelytra, at least the cuneus distinctly lighter in color than disc of corium.
i. Cuneus and sometimes spots on corium lighter in color than disc.
j. Thorax with typical markings (see c, above).....var. *cunealis* n. var.
jj. Thorax otherwise marked.
k. Thorax dark or dusky, with light vittæ from just outside discal spots toward posterior margin, and a light central patch sometimes prolonged toward hind margin.
l. Scutellum dark, with distinct median light vitta....var. *par.* n. var.
ll. Scutellum sordid or clouded yellowish.....var. *sordidus* n. var.
kk. Thorax except discal spots and anterior third, scutellum, cuneus and elytral maculations, pale yellow.....var. *lucidus* n. var.
ii. The whole costal margin reddish or yellowish.
m. Thorax without dark markings between discal spots and hind margin.
n. Discal boot-jack shaped area dark, bounded by lighter elytral margins, scutellum and thorax.....var. *bidens* n. var.
nn. This marking practically obsolete; upper surface except membrane, inner angle of corium and base and thin inner margin of clavus reddish or yellowish.....var. *ardens* n. var.
mm. Thorax with dark markings between discal spots and hind margin.
o. Typical dark marking on anterior third of thorax.
p. Scutellum dusky with median light vitta.
q. Clavus and adjacent parts of corium, and the membrane dusky.....var. *nubilus* n. var.
qq. Clavus and adjacent parts of corium spotted with yellowish red.....var. *delta* n. var.
pp. Scutellum mostly light; median light vitta, bounded by two more or less complete wedge-shaped dark ones; clavus and corium spotted with yellow.....var. *varius* n. var.
oo. No dark marking on anterior third of thorax..var. *bicolor* n. var.

Paracalocoris scrupeus var. **scrupeus** Say. (Loc. cit.)

Head in lightly marked individuals fuscous with pale yellow lineations medially above, over and under eyes and antennal sockets and across front of tylus; under surface of head pale yellow. All these markings may be more or less obscured by fuscous. Antennæ fusco-piceous, 3rd and 4th joints sometimes pale at base. Thorax and scutellum orange (orange chrome)* to pale red (jasper red); anterior third of thorax dusky to piceous, and dots or more or less clouding in same colors near posterior angles; scutellum more or less margined with dusky to piceous, median line often paler than ground color. Sides of prothorax with alternating pale and fuscious lines, usually connected by at least an oblique pale streak on meso and meta-thorax, to the pale markings along sides of venter.

Hemelytra fusco-piceous, tending in some specimens to show a reddish tinge, especially at the cuneus; membrane dusky.

Legs fusco-piceous, femora sometimes with pale yellow maculations and front and intermediate tibiæ with one, hind with 2 pale annuli. Venter pale fuscous to piceous; lightly pigmented individuals have from one to three series of pale markings across outer parts of abdominal segments.

*When convenient, color names were taken from Color standards and color nomenclature,, by Robert Ridgway, Washington, D. C., 1912.

Batavia, N. Y., 19♂, ♀, June 20-27. On Crataegus, wild apple, and wild cherry. H. H. Knight. (K, M.)† A specimen without locality bears the label "on oak." (N. M.)

Niagara, N. Y., July 5, 1904, 1 ♀ (H.).

Beltsville, Md., June 9 and 14. 3 ♂ ♀ on Psedera quinquefolia. W. L. McAtee (M.). One of these specimens has intensified thoracic markings, and approaches var. *triops* (see below).

Bluemont, Va., July 1, 1914, 2♂. W. L. McAtee. (M.)

Paracalocoris scrupeus var. **rubidus** n. var.

Head much as in typical variety; first joint of antennæ reddish testaceous to reddish and fuscous at base. Thorax and scutellum orange red (dragons blood red to Brazil red), dusky markings near posterior angles of thorax almost or quite obsolete.

Hemelytra chiefly dark red (morocco red), varying to piceous on clavus and apex of corium; costal edge of corium with small dull testaceous patches; cuneus blood red (garnet brown) to morocco red; membrane dusky.

Femora pale spotted and tibiæ each with two light and three dark annuli, the terminal one of latter narrow; these markings sometimes obsolete.

Batavia, N. Y., June 28, 1914, 1 ♀, H. H. Knight, Type.(K.)

Stony Island, N. Y., July 8, 1896, 1 ♀ (N. M.)..

Paracalocoris scrupeus var. **triops** n. var.

Coloration as in typical variety except that thorax has much more extensive dark markings. A median area between discal spots, sometimes extending more or less toward hind margin and two areas just laterad of discal spots and continuing over sides, yellowish or reddish. Scutellum more heavily margined with piceous than in typical variety.

A pale (immature) specimen of this variety has the femora and basal joints of antennæ pale yellowish maculate.

A very dark specimen has discal thoracic marking reduced in size, and two triangular piceous markings bordering median line at base of scutellum.

Pine Island, N. Y., June 19, 1912. 1 ♀, Wm. T. Davis, Type (K.).

Staten Island, N. Y., June 17, 1912. 1 ♂ Wm. T. Davis, (H.).

1 ♀ without locality (N. M.).

†The initials in parentheses indicate present owners of specimens. Those used and their significance are as follows: D—Wm. T. Davis. H.—Otto Heidemann, K.—H. H. Knight, M.—W. L. McAtee, and N. M.—U. S. National Museum.

Paracalocoris scrupeus var. **diops** n. var.

Coloration as in typical variety except that scutellum is entirely fusco-piceous, and thorax of same color except for yellow patches laterad of discal spots, which extend irregular projections toward hind margin. There are faint pale points also along median line.

1 ♂ Lakehurst, N. J., June 30. Wm. T. Davis. Type (H.)

Paracalocoris scrupeus var. **percursus** n. var.

A pale variety; head pale testaceous, an oval patch of dark herring bone markings between bases of antennæ, which is traversed by a pale vitta extending forward over tylus; patch on side of latter and stripe from front of eye to tylus shining light brown. Antennæ testaceous, first joint sprinkled with reddish brown or fuscous markings; second joint with same color varying in extent at base and apex; third and fourth joints more or less broadly tipped with same.

Thorax with a median percurrent area of varying extent pale testaceous; remainder of upper surface more or less fuscous irrorate or vittate.

Scutellum pale testaceous, median percurrent area clear; remainder with fuscous markings which tend to be arranged in two pairs of vitta, one set paralleling median clear area and the other lying on lateral margins of scutellum.

Hemelytra yellow-brown (hazel), clavus narrowly edged internally with black; cuneus yellowish red (rufous); membrane dusky with clearer areas.

General color beneath pale testaceous; the series of markings along sides which in the typical variety contrast with the ground color, here are of that color, but are set off by more or less fuscous edgings. Legs testaceous, fuscous irrorate.

In this variety the pilosity of hind tibiæ is rather sparse; the first joint of antenna also is consistently though slightly shorter than thorax; hence the variety is not so closely linked to *scrupeus* as are the others. For the present, however, it seems best to give it the status here assigned. The form is easily recognized by the broad pale marking percurrent over head, thorax and scutellum.

Plummers Island, Md., June 7, 1914, W. L. McAtee. 1 ♂ Type (M.).

Plummers Island, Md., June 30, 1907, A. K. Fisher. 1 ♂ (M.).

Four-mile Run, Va., May 31, 1914, Alex. Wetmore. 1 ♂ (M.).

District of Columbia, 1 ♀ (N. M.).

Paracalocoris scrupeus var. **compar** n. var.

Head sordid-testaceous; area between bases of antennæ with faint fuscous herring-bone markings broken along median line. Antennæ: First joint, pale fuscous; second joint, apical third and narrow ring at base fuscous, remainder testaceous; third joint, apical third fuscous, remainder testaceous.

Thorax above sordid-testaceous in front of discal spots, elsewhere vinaceous red with indistinct paler areas. Scutellum reddish-fuscous with median reddish-yellow vitta. Corium red-brown with reddish-yellow spots; fuscous at apex. Clavus fuscous along inner margin. Cuneus clearer red-brown with clustered reddish-yellow spots. Membrane vitreous, dusky clouded.

Color beneath mostly reddish fuscous with reddish yellow markings. Legs sordid-testaceous; usual dark markings faintly indicated.

West Point, Nebr., June, 1888. 1 ♂, Type (N. M.).

This variety is almost a perfect match in color for some specimens of *P. colon* var. *colonus*.

Paracalocoris scrupeus var. **cunealis** n. var.

This differs from typical variety only in always having the cuneus of a lighter color than disc or corium, that is yellowish to reddish; usually a few spots of the same color elsewhere on hemelytra, especially on the part next to cuneus. Basal part of cubitus also usually pale.

Batavia, N. Y., June 20 to July 6. Numerous specimens. H. H. Knight. On wild apple, Crataegus and Quince. (K, M.) 1 ♂, June 27, 1913 is the type. (K.)

Onaga, Kansas, 1 ♂, Crevecocur. (N. M.)

Paracalocoris scrupeus var. **lucidus** n. var.

Similar to last, but thorax except discal spots and part anterior to them, scutellum, cuneus, elytral maculations, and cubitus, pale yellow.

Batavia, N. Y., July 6, 1914. 1 ♀, H. H. Knight. Type (K.).

Paracalocoris scrupeus var. **par.**

Head and antennæ as in typical variety.

Thorax above fusco-piceous except narrow yellowish-to reddish-orange vittæ beginning just outside discal spots and extending to near hind margin, a central patch of same color sometimes prolonged toward hind margin; and sometimes also smaller spots elsewhere. Scutellum fusco-piceous with more or less distinct yellowish to reddish orange median vitta; sometimes traces of two other vittæ midway between median one and basal angles. Hemelytra fusco-piceous; cubitus,

maculations (sometimes indistinct) near margin, especially toward cuneus yellowish to reddish yellow. Cuneus sometimes of same coloration, but varying to clearer reddish (Brazil red). Membrane dusky.

Legs with light markings rather pronounced. Coloration much like that of *P. hawleyi* var *pallidulus* n. var.

Ithaca, N. Y., June 21, 1915. 1 ♂, Type (K.).

Same data, 1 ♀. Batavia, N. Y., June 20, 1915, 1 ♂.

Portage, N. Y., June 27, 1915. 1 ♂. All collected by H. H. Knight. (K, M.)

Rochester Jct., N. Y., June 16, 1914, 1 ♂. M. D. Leonard. (H.)

Willow Springs, Ill., July 3, 1904. 1 ♀. On wild grape. W. J. Gerhard. (H.)

West Point, Nebr., May 26, 1885. 1 ♀ and a ♂, with label Nebr. (N. M.)

Paracalocoris scrupeus var. **sordidus** n. var.

Similar to variety *par*, the principal difference being that scutellum except the sloping lateral portions is sordid yellowish, paler along median line. The maculations of hemelytra are not so distinct as in *par* and the dark markings of thorax tend to be merely fuscous cloudings.

Batavia, N. Y., June 30, 1914. 1 ♂. H. H. Knight. Type (K.)

Nebraska, 1 ♂. (N. M.)

Paracalocoris scrupeus var. **bidens** n. var.

Head and antennæ as in typical variety.

Thorax with typical markings, except that clouding near posterior angles may be absent. There are in some specimens traces of dark markings at middle of hind margin of thorax and on anterior median part of scutellum. Scutellum sometimes rather sordid with lighter median vitta. Otherwise, thorax, scutellum, and broad lateral portions of hemelytra, yellowish to red, brightest on cuneus; enclosing a discal boot-jack shaped fuscous to piceous area, which is sometimes invaded by pale maculations. Membrane dusky.

I group with this variety all specimens varying toward var. *ardens* (see below), but not clearly that form.

Beltsville, Md., June 14, 1914, on Virginia creeper, 1 ♂ Type. W. L. McAtee (M.).

Pine Island, N. Y., June 14, 1912, 1 ♂, and Staten Island, N. Y., June 17, 1 ♂. Wm. T. Davis (D.).

Batavia, N. Y., June 14 to 30, many specimens. On wild apple and Crataegus. H. H. Knight (K, M.).

Ithaca, N. Y., June 21, 1915. 1 ♀ and June 1911, 1 ♂. H. H. Knight (K.).

Lakehurst, N. J., June 30, 1 ♀; Singae, N. J., June 15, 1 ♂, and Ramsey, N. J., June 23, 1912, 1 ♀. Wm. T. Davis (D.).

Allegheny, Pa., no date, 1 ♀. (N. M.)

Beltsville, Md. Numerous specimens, June 9 and 14 and July 4. On *Psedera quinquefolia*. W. L. McAtee (M, K.).

Plummers Island, Md., June 5, 1903. 1 ♂, W. V. Warner (N. M.).

Washington, D. C., August 9, 1884. 1 ♂ (H.).

Bluemont, Va., July 1, 1914. On Virginia creeper. 2 ♀, W. L. McAtee (M.).

Victoria, Texas, April 11 and 20. On *Quercus virginianus*. 1 ♂, 1 ♀, J. D. Mitchell (N. M.).

One ♀, without locality, but with label, "on oak," June. (N. M.)

Paracalocoris scrupeus var. **ardens** n. var.

Upper surface yellowish to reddish, practically without dark markings; faint dark markings tend to persist at apex of corium, along inner edge of corium and clavus and on vertex. Membrane smoky.

Willow Springs, Ill., July 3, 1904. On wild grape. W. J. Gerhard. 1 ♀. Type (H.)

Great Falls, Va., May 30, 1907. 1 ♀. O. Heidemann. (H.)

Chain Bridge, Md., June 9, 1905. 1 ♀. D. H. Clemons (N. M.)

Paracalocoris scrupeus var. **nubilus** n. var.

Head and antennæ as in typical variety.

Thorax above fuscous before discal spots, two widening fuscous vittæ extending from discal spots to hind margin of thorax. Thorax elsewhere dusky vinaceous red, fading to yellowish just outside each discal spot and along median line behind.

Scutellum fuscous, fusco-piceous at base, reddish elsewhere with yellowish brown median vitta.

Clavus and adjoining parts of corium, and apex of latter fusco-piceous. Remainder of corium reddish, variegated with paler; cuneus clear light reddish, fuscous at apex. Membrane dusky with faint pale areas.

Portage, N. Y., June 21, 1914. 1 ♂ Type. H. H. Knight (K.).

Paracalocoris scrupeus var. **delta** n. var.

Head as in typical variety; antennæ, first joint, fuscous at base, testaceous sprinkled with reddish fuscous beyond; second to fourth each fuscous with a narrow testaceous annulus at middle, another at base.

Thorax above chiefly piceous; yellowish red to orange red sprinklings as follows: About discal spots and in three pseudovittæ toward hind margin, one outside each discal spot and one median, the latter diffuse; also a series of spots near hind margin.

Scutellum fusco-piceous with narrow orange-red median vitta. Clavus fusco-piceous sprinkled with reddish yellow along outer edge. Corium orange-red, spotted with yellow, fusco-piceous along cubitus and at apex. Cuneus clearer reddish with a few yellowish spots. Membrane dusky with large pale areas.

Color beneath fuscous to piceous the usual markings in yellowish and reddish; legs fuscous, femoral spots and tibial annuli testaceous.

Willow Springs, Ill., July 3, 1904, 1 ♀. On wild grape. W. J. Gerhard. Type. (H.)

Paracalocoris scrupeus var. **varius** n. var.

Head, antennæ and legs pale, but with the typical markings recognizable.

Thorax above reddish-orange, with transverse band in front of discal spots and broken vittæ from latter to hind margin, fuscous to piceous; sometimes sprinkled with pale fuscous or yellowish elsewhere.

Scutellum of same reddish-orange color or somewhat darker with paler median vittæ, set off by dark markings beginning at base and extending varying distances apically. Hemelytra of same ground color; clavus and apex of corium fuscous, sometimes fuscous cloudings elsewhere and usually yellow flecks paler than ground color. Cuneus clearer reddish. Membrane dusky with pale areas.

Batavia, N. Y., June 27, 1913. On wild apple. 1 ♀. Type. H. H. Knight (K.) Two other females with same data. (K, M.)

Paracalocoris scrupeus var. **bicolor** n. var.

Head rather pale, antennæ piceous, legs reddish fuscous.

Thorax above, reddish in front of discal spots, and between them, the latter marking extending toward hind margin, which is narrowly edged with reddish; remainder of upper surface fusco-piceous.

Scutellum dark red, lighter at base and apex.

Hemelytra fusco-piceous, except base of cubitus, narrow costal margin, apex of clavus and cuneus, which are dark red. Membrane fuscous.

Victoria, Texas, April 20. On live oak. 1 ♂. Type. J. D. Mitchell. (N. M.)

Paracalocoris adustus n. sp.

Length 8 mm., length of thorax 1.46 mm.; width of thorax, front, .8 mm., back 2.2 mm.; length of antennal joints: first 1.6 mm.; second 2.53 mm.; third 1.16 mm.; fourth 1.1 mm.

Color an almost uniform reddish brown, a little lighter on cuneus and lower surface and inclining to fuscous on antennæ, tibiæ and inner margin of elytra; membrane dusky. Short pale yellow hairs abundant on upper surface, except membrane.

Lakehurst, N. J., June 13, 1908, 1 ♀ (Type), Wm. T. Davis (D.).

Paracalocoris hawleyi H. H. Knight, n. sp.

Elongate and more slender than *P. colon*. Color, fusco-piceous to piceous, rubiginous in immature specimens, with outer margin of the hemelytra sordid hyaline or pale yellowish and cuneus reddish. Pubescence more sparse and not noticeably golden yellow, as in *P. colon*. Total length 6 mm.

♂. Head: Eyes and face dark brownish to black; posterior part of the eyes, a semicircular mark between and in front of the eyes, nearly joining across the vertex, pale to orange-red. Width of head across the eyes, 1.08 mm., width between eyes, .51 mm., length of dorsal aspect, .6 mm. Rostrum reaching to posterior margin of the hind coxæ, amber brown or fuscous, two basal segments more or less pale at apex; two apical segments darker. Antennæ: Segment I, length 1.37 mm., reddish black, densely hairy with a few scattering spines which stand out from the partly decumbent hairs; segment II, length 2.2 mm., thicker on apical half, brownish black with fine pubescence; segment III, length 1 mm., blackish, pale at the base, with very fine silvery pubescence; segment IV, length 1.19 mm., like the preceding, only slightly more slender.

Pronotum: Length 1.14 mm., width of base 1.88 mm., apex .82 mm.; color fusco-piceous, sometimes with apical half yellowish; front, sides and a very narrow margin extending around base of pronotum, pale; two jet-black, opaque, sub-excavated spots, one behind each callus, with a pale area bordering the outer margin of each. Scutellum fusco-piceous with a pale median, longitudinal line or trace thereof, some specimens having this line produced on the pronotum.

Hemelytra: Greatest width 2.02 mm.; clavus fusco-piceous as is that part of the corium inside of the cubital vein; corium exterior to the cubitus, pale yellowish, sometimes tinged with orange; cuneus reddish orange with basal and narrow outer margin paler; membrane and veins fuscous, with a clear spot along the margin near the apex of the cuneus.

Legs fusco-piceous, with small pale yellowish to reddish spots on the femora especially near the apices; hind tibia with two pale rings, sometimes not distinct, the larger taking up of the apical fourth; tarsi pale,

with the tips fuscous. Venter fusco-piceous, a series of 3 or 4 narrow pale lines on its margins in some specimens reduced to spots.

Female essentially the same as the male, but slightly more robust and especially so when filled with eggs. In typical specimens both sexes are of the same color.

Paracalocoris hawleyi var. **ancora** Knight, n. var.

Similar to *hawleyi*, but differs in having the hemelytra entirely fusco-piceous, cuneus dark reddish with the very apex fuscous; costal vein and base of cubitus noticeably pale; median longitudinal pale stripe of scutellum quite plain and is usually joined by a similar stripe extending from the base of the pronotum forward between the two sub-excavated black spots.

This species and variety are described from a large series of specimens collected on hop vines near Waterville, N. Y., from July 18th to September 1, 1914 and 1915. The writer has seen two specimens from Brookline, Mass.

The species is named for Mr. I. M. Hawley, who during the last two years has worked out the life history of the insect near Waterville, N. Y., where it is becoming a pest of economic importance on the cultivated hop. The life history of the species will soon be published by Mr. Hawley.

P. hawleyi and *P. colon* both may be distinguished from *P. scrupeus* and its varieties by the shortness of the pubescence on the posterior tibiæ, which is never long and prominent enough to obscure the true spines. *P. hawleyi* differs from *P. colon* in being more slender and elongate; hemelytra more parallel-sided and in color, fusco-piceous with outer margin pale or reddish yellow; variety *ancora* with the hemelytra almost entirely fusco-piceous without the pale margin. The pubescence of *P. hawleyi* is more sparse and less golden yellow; dorsum not variegated with paler maculæ as in the case in our local variety of *P. colon*. *P. hawleyi* feeds on hops and appears later in the season than *P. colon*. In 1915 the species began maturing about July 18th and adults continued to emerge up into the first week in August. Adults were most numerous from July 25 to August 20, while occasional adults are found in September. *P. colon* was found breeding in considerable numbers on the tender shoots of apple trees near Batavia, N. Y. In 1915 the first adult was taken June 19th and the majority of the species had emerged by July 7. Adults were very scarce by July 23 and none were taken after July 31.

The writer of the present paper desires to name two other color varieties of *Paracalocoris hawleyi*. These and the two described by Mr. Knight may be distinguished as follows:

A. With lateral pale stripe whole length of corium.
  B. This stripe undivided, though it may contain a dark blotch especially at about middle of costal margin..... var. **hawleyi** Knight.
  BB. Stripe divided by a dark vitta broader posteriorly, leaving a very narrow pale costal margin..... var. **fissus** n. var.
AA. Without such stripe.
  C. Hemelytra except cuneus almost uniform in color, though cubitus and costa may be pale..... var. **ancora** Knight.
  CC. Hemelytra and other parts of upper surface more or less spotted with yellow..... var. **pallidulus** n. var.

Immature specimens are reddish throughout, though the color pattern is indicated by different shades. Specimens nearly mature may be dusky red, but when fully mature the ground color of *hawleyi* is fusco-piceous to piceous.

Paracalocoris hawleyi var. **hawleyi** Knight.

Waterville, N. Y., July 23, 1915, I. M. Hawley, 1 ♂ (Holotype) (K.).

Waterville, N. Y., July 27, 1915, I. M. Hawley, 1 ♀ (Allotype) (K.).

Waterville, N. Y., July 27 to August 18, 1915, I. M. Hawley, 3 ♂, 2 ♀ (K, M., N. M.).

Waterville, N. Y., July 7, 1913, G. W. Herrick, 4 ♂ (N. M., H.). These specimens are all immature and are very reddish. Another male with same date (H.) has thorax largely, costal stripe, tips of clavi and other pale markings ochreous and cuneus pale sanguineous.

Waterville, N. Y., August 5, 1913, I. M. Hawley, 1 ♂ (H.).

Beltsville, Md., June 14, 1914, W. L. McAtee, 4 ♂, 2 ♀ (M.).

Paracalocoris hawleyi var. **fissus**. n. var.

Differs from *hawleyi* in having the pale costal margin divided by a mahogany red to fuscous streak from humerus to cuneal suture. This streak, which is broader posteriorly, leaves only a thin pale costal streak and a wider but more irregular one along cubitus. Two specimens have a pale streak along claval vein, and a shorter one along brachial vein.

Beltsville, Md., June 14, 1914, W. L. McAtee, 1 ♂ (Type) (M.).

Same data also 3 ♀, 1 ♂ (M.).

Staten Id., N. Y., June 19, W. T. Davis, 1 ♂ teneral, and color not fully developed. (D.)

Paracalocoris hawleyi var. **ancora** Knight.

Waterville, N. Y., August 2, 1914, I. M. Hawley, 1 ♂, (Holotype) (K.).

Waterville, N. Y., August 21, 1914, I. M. Hawley, 1 ♀, (Allotype) (K.).

Waterville, N. Y., August 18-22, 1914, August 1-18, 1915, I. M. Hawley, 5 ♂, 1 ♀, (K, M., N. M.).

Waterville, N. Y., July 7, 1913, G. W. Herrick, 1 ♂, immature (N. M.).

Waterville, N. Y., August 5, 1913, I. M. Hawley, 1 ♂, (H.).

Ithaca, N. Y., upon hops, G. W. Herrick, 1 ♂, immature (H.).

Batavia, N. Y., July 15, 1913, June 24 to July 26, 1914, July 27-31, 1915, H. H. Knight, 6 ♂, 1 ♀, (K, M.).

Beltsville, Md., June 14, 1914, W. L. McAtee, 4 ♂, (M.).

Paracalocoris hawleyi var. **pallidulus** n. var.

Agrees with *ancora* in lacking broad pale costal margin, but differs from that variety in having the corium especially posteriorly, and usually the scutellum and thorax, dotted with small pale yellowish spots in addition to the usual pale markings.

Batavia, N. Y., June 24, 1914, H. H. Knight, 1 ♀, Type (K.).

Same locality, July 25, 1913, June 30, 1914, July 25 and 30, 1915, H. H. Knight, 3 ♀, 1 ♂, (K, M.).

Paracalocoris limbus n. sp.

Length 7.5 mm.; length of thorax 1.56 mm., width of thorax: Front, 1 mm., back 2.33 mm.; length of antennal joints: First 1.5 mm., second 2.56 mm., third 1.16 mm., fourth 1.33 mm.

Top of head, a marking on base of thorax, with anterior lobes reaching discal spots, and shorter lobes outside of these, scutellum and hemelytra except broad exterior margins fuscous; membrane dusky. Remainder of upper surface yellowish red, palest on edge of corium, deepest on front of thorax. First joint of antenna piceous, with copious coarse hair of same color; color of remaining joints and pubescence thereof successively paler, the third being fuscous, and the fourth testaceous with abundant, fine whitish hair.

Legs fusco-piceous, spots on femora and the tarsi pale. Under surface yellowish red with fuscous markings.

Clayton, Ga., 2000-3700 ft., June, 1909, 1 ♀ (Type), Wm. T. Davis, (K.).

Paracalocoris colon Say.

C. [apsus] colon Say. Heteropterous Hemiptera of North America. New Harmony, Indiana, Dec., 1831. p. 25. Complete writings, Vol. I. 1859. pp. 346-347. (Indiana).

It is not absolutely certain that the name *colon* is applied here to the precise form described by Say. For instance, Say describes the second antennal joint of *colon* as "whitish in the middle and for a short space at base, and blackish at tip." As color characters go in *Paracalocoris* those of the antennæ are perhaps the most constant. Yet in all the specimens, I have examined of what is here accepted as the *colon* group, not one agreed with the original description in coloration of the second joint of the antenna. *Paracalocoris multisignatus* Reuter, however, agrees perfectly in this particular and is the only species having just that coloration. Nevertheless the remainder of the description of *colon* does not fit *multisignatus*, and in particular the conspicuous pale spot invariably present on apical third of scutellum of the latter species is not mentioned. This could hardly be overlooked. In the absence of type specimens, therefore it is best to preserve the names as they are customarily applied. It is possible, futhermore, that a specimen of the typical variety with proper antennal coloration may sometime be found, in which case all doubts will be removed.

Description of Nymphs.

Two nymphs evidently of this species, collected at Beltsville, Md., June 9, 1915, on Psedera quinquefolia, W. L. McAtee (M.), may be characterized as follows:

Length 4-4.5 mm.; length of thorax .66 mm.; width of thorax: front .703-.806 mm.; back 1.2 mm.; distance from back of thorax to tip of wing pad 1.6 mm.; length of antennal joints: first 1 mm.; second, 1.8 mm.; third .8-1 mm.; fourth .806 mm.

General color, yellowish green or sordid testaceous; fusco-piceous on tips of wing pads, and sometimes on head. Antenna: first joint light greenish to reddish, with copious black pile; second joint, basal two-fifths, stramineous, remainder reddish, varying to piceous, with copious black pile, more abundant apically; third joint greenish, apical third blackish, also with longer and more copious pile than usual; fourth joint pale. Femora when marked, reddish or fuscous with yellowish spots; tibiæ with two dark and two pale annuli; tarsi dark at tip.

Paracalocoris colon may be divided into color varieties as follows:

A. Hemelytra entirely pale (stramineous to reddish) or with markings (besides that at apex of corium) darker than ground color.
B. Hemelytra pale, with conspicuous dark spots or cloudings..var. **colon** Say.
BB. Hemelytra practically unicolorous pale.....var. **castus** n. var.
AA. Hemelytra entirely dark (reddish-brown to blackish-fuscous) or with markings lighter than ground color.
C. Thorax varying from reddish to fuscous or fuscous clouded or vittate; thorax usually, and hemelytra always more or less spotted with pale yellow.....var. **colonus** n. var.
CC. Thorax as in last variety; hemelytra almost or entirely lacking yellow spots.....var. **amiculus** n. var.

Paracalocoris colon var. **colon** Say (Loc. cit.)

Length 7 mm.; length of thorax 1.46 mm.; width of thorax: front .83 mm.; back 2.2 mm.; length of antennal joints: first 1.2 mm., second 2.13 mm., third .86 mm., fourth .7 mm.

Ground color stramineous to testaceous; plentifully pilose with short white to golden hairs.

Head with faintly indicated herring bone pattern, interrupted along median line, sometimes with dusky clouding above. Antennæ testaceous, the basal joint somewhat reddish; narrow annulus at base and apical third of second joint, piceous; third and fourth each darker toward apex.

Thorax with following fuscous markings: spots near anterior angles or transverse band behind stricture, widening vittæ from discal spots to posterior margin, and vittæ along lateral margin outside of former pair, the two sometimes merged.

Scutellum with fuscous mark near base and indications at least of narrow median pale vitta. Clavus within, irregular blotches on corium near clavus, on middle of costal part of corium, apex of corium and apex of cuneus, fuscous. Membrane vitreous with fuscous clouding. Lower surface variegated with ground color and fuscous, the latter covering most of the genital segment and under surface of thorax. Legs with pale fuscous to fusco-piceous irrorations near apices of all femora and near bases of hind femora; traces at least of two dark and three light annuli on tibiæ; tarsi dark apically.

Staten Id., N. Y., June 17, 1 ♂ (H.) and 1 ♀ (D.), Wm. T. Davis.

Paracalocoris colon var. **castus** n. var.

Length 5.5-7 mm.; length of thorax 1.5-1.6 mm.; width of thorax: front .8-.9 mm.; back 1.5-1.6 mm.; length of antennal joints: first .83-1 mm.; second 1.93-2.06 mm.; third .8 mm.; fourth 1 mm.

The color varies from sordid stramineous to light reddish-brown. There are no distinct markings on head or body above besides discal spots on thorax and dusky to piceous spots on apex of corium and dusky or clouded membrane. The cuneus varies from stramineous spotted

with reddish-yellow to clear reddish. Antennæ as in typical variety sometimes paler, last joint sometimes almost wholly fusco-piceous. Legs and under surface as in typical variety but lighter.

Beltsville, Md., July 4, 1915. On Psedera quinquefolia, W. L. McAtee, 1 ♀, (type), (M.).

Haverstraw, N. Y., July 4, 1897, 1 ♀, (N. M.).

Staten Id., N. Y., August 17, W. T. Davis, 1 ♂, (D.).

Beltsville, Md., June 14, 1914, 1 ♀, W. L. McAtee, same date as type, 4 ♀, 1 ♂, W. L. McAtee, (M.).

Washington, D. C., June 23, 1905, 1 ♂, 1 ♀, O. Heidemann (H.).

Illegible locality, 2 ♀, (N. M.).

Paracalocoris colon var. **colonus** n. var.

Length 5.5-7 mm.; length of thorax 1.1-1.4 mm., width of thorax: front .76-.96 mm.; back 1.76-2.1 mm.; length of antennal joints: first .93-1 mm.; second 2.06-2.2 mm., third .8-.806 mm.; fourth .903-1 mm.

Head testaceous, with usual herring bone pattern and some blotches, pale fuscous to fuscous; eyes reddish testaceous, blotched or clouded with same color. Antennæ about as in typical variety, first joint in particular sometimes darker. In distinctly marked forms first joint may be yellowish spotted, and pale yellowish part of second joint broken by a wide pale fuscous band.

Thorax red-brown to fusco-piceous or with clouding or more definite transverse marking behind apical stricture, and broad vittæ from discal spots to hind margin fuscous or fusco-piceous. Area laterad of these vittæ sometimes also of same color. Areas in front of and sometimes surrounding discal spots, spots along median line and often elsewhere, yellowish-testaceous.

Scutellum fuscous to fusco-piceous, usually with median vitta or traces of it at least apically, extreme apex, and submarginal vittæ or traces thereof pale yellowish.

Hemelytra reddish-brown to fusco-piceous with scattered pale yellowish spots (tending to be longitudinally elongate), especially numerous near and in cuneus. In extreme forms these agglomerated into patches along cubitus; clavus usually only slightly marked. Cuneus more reddish than any other part of hemelytra. Membrane vitreous with fuscous clouding to almost black; apex of corium fuscous to fusco-piceous.

Legs more heavily marked than in preceding varieties; femora irrorate with or largely reddish to fusco-piceous, spotted with yellowish; tibiæ also yellow spotted and tending to have two dark and two pale annuli; tarsi darker toward tips. Under surface variegated with yellowish and fuscous; three dark and two light bands on side of head, under side pale fuscous; sides of prothorax with 2 narrow pale bands, each bordered on both sides by darker color, the lower at least repre-

sented by a distinct yellowish, fuscous-bordered spot, above insertion of front leg; a pale vitta across side of meso- and meta-thorax, and a series of about three dark and three pale bands on sides of abdominal segments. These markings may be traced in dark specimens of the other varieties of colon.

Rather a heterogenous assemblage, but on account of overlapping variations not easily divisible into smaller groups.

Well-marked dark specimens of this variety answer well to the description of *Paracalocoris attenuatus Distant**, but in the absence of authentic specimens of that form, it is preferable to use a different name. If the two forms are later found to be identical, the fact can easily be indicated.

Bluemont, Va., July 1, 1914, W. L. McAtee, 1 ♂ (Type) (M.).

Middlebury, Vt., July, 1912, 1 ♂, (K.).

Haverstraw, N. Y., July 4, 1897, 3 ♂, (N. M.).

Lancaster, N. Y., August, 1886, 1 ♀, (N. M.).

Greensburg, Pa., July 25, 1 ♀, M. Wirtner, (H.).

Lake Hopatcong, N. J., July 4, 1913, 1 ♀, W. T. Davis, (K.).

Trenton, N. J., 2 ♂, (H.).

Beltsville, Md., June 14, 1914, 2 ♂, July 4, 1915, on Psedera quinquefolia, 1 ♂, W. L. McAtee, (M.).

Bluemont, Va., July 1, 1914, W. L. McAtee, 2 ♂, (M.).

Paris, Fauquier Co., Va., July 27, 1890, on wild grape, O. Heidemann, 1 ♀, (H.).

Missouri, C. V. Riley, 1 ♀, (N. M.).

Ft. Collins, Colo., July 21, 1899, E. D. Ball, 3 ♀, 2 ♂, (N. M., H.).

Paracalocoris colon var. **amiculus** n. var.

Similar to last, but hemelytra almost or entirely lacking yellowish spots. Cuneus reddish, usually more or less yellowish spotted, membrane and apex of corium dusky to black. Legs and antennæ darker than in last variety.

Beltsville, Md., July 4, 1915. On Psedera quinquefolia, W. L. McAtee, 1 ♂, (Type) (M.). Same data, 1 ♀, (M.).

Plummers Id., Md., June 17, 1906, W. L. McAtee, 1 ♂, (M.).

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*Biologia Centrali-Americana. Insecta, Rhynchota, Hemiptera-Heteroptera, Vol. I, p. 264, Feb., 1884 (San Geronimo, Cautemala; Bugaba, Panama).

Paracalocoris heidemanni Reuter.

Paracalocoris heidemanni Reuter, O. M. Bemerkungen uber nearktische Capsiden nebst beschreibung neuer Arten. Acta Societatis Scientearum Fennicae, 36, No. 2, 1909, p. 40. (Aurora, W. Va., August 19, 1904,* O. Heidemann).

Length 6-7 mm.; length of thorax 1.23-1.3 mm.; width of thorax: front .66-.73 mm.; back 1.8-193 mm.; length of antennal joints: first 1-1.16 mm., second 1.93-2.06 mm., third .9-.93 mm., fourth .96-1.06 mm.

Range: The known range comprises only Maryland, Virginia and West Virginia.

Two color varieties may be distinguished as follows:

A. Vitta overlying cubital vein contrasting decidedly in color with adjacent parts of corium.....var. *heidemanni* Reuter.
AA. Corium practically uniform in color.....var. *ablutus* n. var.

Paracalocoris heidemanni var. **heidemanni** Reuter. (Loc. cit.)

The form described below must be regarded as the typical variety, although Reuter's description of the ground color of hemelytra as fusco-testaceous or isabelline, by no means suggests the rich mahogany-red color of most of the specimens.

Fully colored specimens are as follows: Head reddish testaceous, with herring bone pattern on vertex in a darker red brown; eyes piceous. Antennæ dark red-brown, first joint sprinkled with yellow, and as a whole with the following piceous markings: Extreme apex of first joint, narrow basal annulus and apical half of second; apical 4-5 of third and fourth joints.

Ground color of upper parts a rich mahogany red, deepest on corium, with the following yellow or golden markings; thorax anterior to apical stricture, a median vitta and two others just outside discal spots extending to and broadening at posterior margin of thorax; narrow median and broader marginal vittæ on scutellum; streak on corium, bordering basal half of clavus, clavus along commissure, vitta along cubitus to apex of corium, narrow costal margin and sometimes a small isolated spot at center of apical margin of corium. Cuneus somewhat deeper in hue than ground color of corium. Membrane dusky, with paler areas and pale reddish vein. Legs pale reddish, femora yellow spotted. Under surface marked with yellow and mahogany red; a series of two dark and three light stripes along side of thorax and about three dark and four light, interrupted vittæ on sides of body segments.

In the paler specimens that may be said to have cubital vittæ, the ground color is yellow-brown to which the cuneus retaining its reddish cast is in distinct contrast.

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*Should be August 16.

Plummers Island, Md., July 19, 26 and August 9, 1914. On Hypericum prolificum. Numerous specimens. W. L. McAtee, (M.). August 4 and 11, 1907, 1 ♀, 1 ♂, W. L. McAtee (H.).

Bladensburg, Md., July 6, 1906, 1 ♂, O. Heidemann, (H.).

Casanova, Va., August, 1912, 1 ♂, O. Heidemann, (H.).

Aurora, W. Va., August 22, 1904, 1 ♀, O Heidemann, (H.).

Paracalocoris heidemanni var. **ablutus** n. var.

This differs from the typical variety chiefly in the general paleness of the ground color, which so approximates that of the vittæ that the latter are scarcely or not distinguishable, especially those on hemelytra. The scutellar and thoracic markings usually are evident. The cuneus is paler than in typical form though still in contrast (pale reddish-brown) to ground color (light orange-yellow). Upper surface with abundant golden hairs as in typical variety. Vein of membrane whitish.

Plummers Island, Md., July 14, 1915. On Hypericum prolificum. 1 ♂, Type, W. L. McAtee (M.). Other specimens from same locality and date; also July 19 and 26. (M.)

Bladensburg, Md., July 6, 1906, 1 ♀, O Heidemann, (H.).

Casanova, Va., August, 1912, 1 ♀, O. Heidemann, (H.).

Hypericum prolificum L. is the true food plant of *Paracalocoris heidemanni* in the vicinity of Washington, D. C., for upon it the nymphs are reared. Occurrence of the species is practically restricted to the flowering season of the plant.

The nymphs in my possession may be described as follows:

Total length 4 mm.; length of thorax, .86 mm., width of thorax, front .83 mm., back 1.6 mm.; distance from back of thorax to tip of wing pad 1.53 mm.; length of antennal joints, first .83 mm., second 1.46 mm., third .83 mm., fourth .8 mm.

Head and thorax sordid testaceous irrorated with reddish. First two joints of antenna rufo-fuscous with abundant coarse black pile. (Only the first joint is so haired in adult). First joint sometimes dotted with yellowish. Third fuscous, pale reddish at base; fourth testaceous to fuscous. Wing-pads sordid rufo-testaceous, these and remainder of upper surface with numerous soft white hairs. Dorsum of abdomen either reddish with a row of yellow dots across each segment, or yellowish with red dots. Legs reddish to fuscous, femora spotted with yellowish. Under surface reddish with yellow spots or the reverse.

Plummers Island, Md., July 14 and 19, 1915. W. L. McAtee, (M.).

Paracalocoris multisignatus Reuter.

Paracalocoris multisignatus. Reuter. Acta Soc. Sci. Fennicæ, 36, No. 2, 1909, pp. 40-41 (Rock Creek, D. C., June 29, 1890, and Washington, D. C., June 22,* 1905. O. Heidemann).

Length 6-7 mm.; length of thorax 1.1-1.33 mm.; width of thorax, front, .56-.66 mm., back 1.63-1.93 mm.; length of antennal joints: first .93-1.06 mm., second 1.86-1.93 mm., third .9-.96 mm., fourth .9-? mm.

A specimen with the markings fully developed has the head reddish cream color, and the eyes stramineous flecked with piceous. The first joint of antenna is fuscous, pale at base; the second stramineous, with a reddish-cream annulus on second quarter from base and the apical quarter fusco-piceous; the last two joints have similar though more obscure markings.

Front and hind margins of thorax, vittæ from latter to discal spots, and band between these pale fuscous, interrupted by small amber yellow spots; leaving three large areas of amber yellow, one on each side extending down over side of thorax and a median sub-basal area.

A large amber yellow spot covers apical third of scutellum; a large spot of same color on cuneus, another just anterior to cuneus and a third midway between this and base of corium. Apex of clavus also amber yellow. Ground color between these areas pale fuscous to blackish brown, with small amber yellow spots. Membrane fumose with paler areas. Legs pale yellow, distal halves or less of femora, two annuli on tibiæ, and tips of tarsi fuscous. Undersurface amber yellow, with fuscous markings on sides of meso- and meta-thoraces, body segments near lateral margins, on middle of subgenital and edge of genital segments.

Principal variations in color are: First joint of antenna may be only fuscous spotted; large amber yellow spots may be obscured either by themselves becoming darker or the ground color paling so as to be almost as pale as the spots. Under surface sometimes wholly pale yellow.

Beltsville, Md., June 14, 1914, 1 ♀, July 4, 1915. On Psedera quinquefolia. 1 ♂, 2 ♀. W. L. McAtee, (M.).

Washington, D. C., June 7, 1884, 1 ♀, O Heidemann, (N. M.).

Hampton, Va., July, (K.).

Texas, 1 ♂, (N. M.).

Paracalocoris jurgiosus Stal.

Calocoris jurgiosus Stal. Hemiptera mexicana enumeravit speciesque novas descripsit. Entomologische Zeitung (Stettin). Jahrg. 23. No. 7-9, July-Sept. 1862, p. 320 (Mexico).

Length 4.5-6.5 mm.; length of thorax 1.16-1.6 mm.; width of thorax: front .66-.73 mm., back 1.73-1.93 mm.; length of antennal joints: first .8-.93 mm., second 1.73-1.83 mm., third .7-.76 mm., fourth .7-.76 mm.

*Should be June 23.

This insect, while furnished with a considerable number of hairs on upper surface, particularly of corium, has a more polished appearance than usual in the genus. The smooth, shiny surface of head, thorax and scutellum is especially noticeable.

Head shining stramineous to reddish testaceous, herring bone pattern faintly indicated. Antennæ reddish testaceous, with following markings: First joint with yellowish spots; second with narrow annulus at base fuscous, one of equal width above it whitish, then about one-third of length of joint of ground color, followed by another narrow whitish annulus, the remainder (nearly half) of joint fusco-piceous; third and fourth joints tipped with fusco-piceous.

The ground color of thorax varies from reddish testaceous to fusco-piceous and the markings from stramineous to amber-yellow. The pattern of markings is as follows: Front margin of thorax a patch between discal spots, and one outside each of them, usually extending as vittæ toward posterior margin of thorax and narrow posterior margin of thorax; on scutellum a narrow median and two broader submarginal vittæ, sometimes broken into dots; on clavus a vitta each side of claval vein; on corium narrow costal margin, vittæ along costal cubital and brachial veins and one paralleling clavus, all usually more or less broken: cuneus with an irregular patch and two longitudinal vittæ. Membrane vitreous to dusky, usually with more hyaline areas and vein in part pale.

Under surface with same colors as upper, a series of 3-5 dark and 3-4 light markings along sides of abdomen; segments pale along posterior margins; a pale vitta underlined by a narrow dark one at top of lateral aspect of pronotum. Legs with same colors, femora banded at middle and sprinkled elsewhere with paler; anterior two pairs of tibiæ dark on basal third, pale elsewhere; posterior or tibiæ with two dark and two pale bands; tarsi fuscous apically.

Brownsville, Texas, June 6, 1895, E. A. Schwarz, 1 ♀.

Brownsville, Texas, June 1, 1907, on cotton. R. A. Cushman, 1 ♀.

San Antonio, Texas, April 18, 1908, W. D. Hunter & F. C. Pratt, 2 ♂, 2 ♀.

Sabinal, Texas, May 26, 1910, F. C. Pratt, 1 ♀.

Hondo, Texas, June 3, 1909, J. D. Mitchell, 1 ♀.

Neuces River, Zanalla Co., Texas, April 29, W. D. Hunter and F. C. Pratt, 1 ♀.

Gregory, Texas, May 30, 1910, W. D. Pierce, 1 ♀.

Devil's River, Texas, May 5, 1907. On sumach, F. C. Bishopp, 1 ♂.

Kennedy, Texas, April 5, 1896. C. L. Marlatt, 1 ♀.

Another specimen from San Diego, Texas, April 25, E. A. Schwarz in teneral condition, possibly is this species. All of the above are in the National Museum collection.

Paracalocoris acceptus n. sp.

Length 6 mm.; length of thorax 1.26 mm.; width of thorax: front .53 mm., back 1.46 mm.; length of antennal joints: first 1.16 mm., second 2.4 mm., third .96 mm., fourth .86 mm.

Head cream color, eyes straw blotched with piceous; first antennal joint blotched with piceous and cream, second fusco-piceous with indistinct cream annulus a little nearer base than apex, third and fourth joints paler, each with a pale ring at base. Pilosity piceous on first joint, fading to white on terminal joints.

Anterior part of thorax and cuneus pale cream color, ground color of remainder of upper surface stramineous, sparsely irrorate with fuscous, the irrorations on thorax and about cuneus varying to fusco-piceous. A complete longitudinal line of this color just below lateral margin of thorax, and one traversing anterior half of thorax just above the margin. Hemelytra lightly margined with fusco-piceous. Membrane fumose, with paler areas paralleling the vein.

Legs stramineous; femora irrorate with fuscous; tibiæ irrorate, but the markings tending to be grouped in four dark annuli, bounding three pale ones; tarsi stramineous basally, fuscous apically.

Under surface stramineous varying to cream, an indistinct fuscous markings across sides of meso- and meta-thorax above coxæ.

Camping place about 3 miles south of San Augustine Ranch, east side of Organ Mountains, New Mexico, August 28, 1894. At light. 1 ♂ Type, T. D. A. Cockerell (H.). Full data kindly furnished by Professor Cockerell.

Paracalocoris deleticus Reuter.

Paracalocoris deleticus Reuter. Uhler ms. Nearktische Capsiden. Acta Soc. Sci. Fennicæ, 36, No. 2, 1909, p. 40. (Lamar, Colo., October 9, 1898, Van Duzee).

Length 6.5-7.5 mm.; length of thorax 1.6-1.66 mm.; width of thorax: front .9-1 mm., back 2.3-2.5 mm.; length of antennal joints: first 1.2-1.23 mm., second 2.3-2.4 mm., third 1-1.06 mm., fourth .83-1.06 mm.

Upper surface polished, with few hairs, except hemelytra, which have numerous inconspicuous short hairs. Ground color stramineous to cream color; herring bone pattern very faintly indicated on head, eyes piceous. Antennæ rufo-testaceous, a little tinged with fuscous near tips of last three joints; last two joints paler near base.

Thorax with faint fuscous to fusco-piceous irrorations near hind margin. Scutellum with one or two faint patches of same color near base. One specimen has a faint orange red patch each side of median line of scutellum near base. Fuscous to fusco-piceous vittæ dotted with ground color, located as follows on hemelytra: One on clavus, and two on corium over the terminal portions of cubital and brachial veins. Faint fuscous clouding along suture between clavus and corium and sometimes elsewhere. Cuneus orange red. Membrane hyaline with faint dusky clouding.

Femora slightly sprinkled or irrorate with usually dark color toward apices; tibiæ slightly dotted, and tarsi darker apically. Scattered dark points or dashes along sides of thorax and abdominal segments.

Clarendon, Texas, September 19, 1905. On sagebrush (Artemisia filifolia). W. D. Pierce, 1 ♂, 2 ♀.

Mesilla, N. Mex., June 15, on flowerhead of Dalea lanosa (Parosela lanata?), T. D. A. Cockerell. 1 ♀. All in National Museum collection.

THE MALPIGHIAN VESSELS OF HALTICA BIMARGINATA SAY (COLEOPTERA).

By William Colcord Woods.*

1. The general structure of the larval vessels.
2. The general structure of the vessels of the imago.
3. A comparison of the conditions in *Haltica bimarginata* with those described for certain other Coleoptera.
4. The function of that portion of the tubes associated with the wall of the colon.

1. THE GENERAL STRUCTURE OF THE LARVAL VESSELS.

INTRODUCTION.

In connection with a study of the internal metamorphosis of the alder flea beetle, *Haltica bimarginata* Say (Chrysomelidæ), a problem which has been occupying the attention of the writer for some months past, observations have been made on the number and arrangement of the Malpighian vessels in these insects. Some striking features were brought out, which seemed worthy of special mention.

THE ALIMENTARY CANAL OF THE LARVA.

In the alimentary canal of the larva of the alder flea beetle, the three primary divisions, fore-intestine, mid-intestine, and hind-intestine can be made out readily. The fore-intestine consists of a short pharynx, a short oesophagus, and a short, thin-walled distensible crop. The mid-intestine, which forms by far the greater part of the canal, is divided into two regions, separated exteriorly by a constriction, each region having a distinct type of epithelium peculiar to it. The hind-intestine consists of three short regions, a small intestine or ileum, a large intestine or colon, and a very muscular rectum. The distinction between these parts is clear as well in dissected specimens as in sectioned material.

Figure 1, a diagram of the alimentary canal, shows the relationship of these parts, although the intestine is actually more convoluted and the folds overlie one another to a greater extent than is there indicated.

*Contribution from the Entomological Laboratory of Cornell University.

THE MALPIGHIAN VESSELS.

From a morphological point of view, the Malpighian vessels of an insect are ectodermal structures, which arise during embryonic life as evaginations of the distal end of the hind-intestine (which is itself an invagination of the ectoderm). In a typical insect, the Malpighian vessels empty into the alimentary canal at the junction of the mid-intestine with the hind-intestine, and after a greater or less course end blindly in the body cavity.

In the larva of *Haltica bimarginata* the arrangement is very characteristic and presents some interesting and rather unusual features. In this insect there are six Malpighian vessels, which are morphologically divisible into two series, differing from one another in point of origin, in length, in macroscopic aspect, and in microscopic structure.

Such a dimorphism in the tubes of the same individual is by no means confined to *Haltica*, but has already been reported for numerous Coleoptera. Indeed, much greater dimorphism has been described for many insects, and while most of the instances cited have been discredited by later workers, it is generally admitted that there is a very decided dimorphism, correlated with a difference in function, in the Malpighian vessels of *Stratiomyia* (Vaney, 1900) and of phasmids (Sinety, 1900).

In *Haltica*, the first series is composed of four vessels which unite at their bases, forming what is generally termed, from analogy with the vertebrates, an urinary bladder. This small ovoid bladder empties directly into the hind intestine, shortly behind its union with the mesenteron. (This condition is illustrated in Figures 1 and 5). At the point of junction of the mid-intestine and the hind-intestine there is a sharp bend, and between the mesenteron which runs caudad and the ileum which extends cephalad, is formed a strong angle, on the inner side of which the bladder opens directly into the lumen of the intestine.

The four vessels leave this bladder in a parallel series so that there are two outer vessels and two inner. These tubes, which are more or less imbedded in the adipose tissue, are long and somewhat twisted, so that it is difficult to trace their course, especially as they are easily broken. They are closely

apposed to the alimentary canal throughout most of their extent, but are always entirely distinct from its walls (except in the colon at their distal ends, as will be explained later). Following very closely the course of the mid-intestine and appressed to its walls, they extend forward as far as the beginning of the crop (i. e., into the mesothorax). Here they bend back on themselves and extend nearly to the posterior end of the body. In a typical cross-section through the meso- or metathorax and the first five abdominal segments, therefore, the mid-intestine is surrounded by eight sections of the Malpighian vessels quite regularly arranged, so that one would naturally interpret them as eight distinct vessels if he did not know the true circumstances of the case. At the constriction between the two parts of the mid-intestine, the Malpighian vessels cease to be associated with the walls of the alimentary canal, and then run posteriorly in the fat body as far as the eighth abdominal segment, where they again double back on themselves, and run cephalad to the sixth abdominal segment. Here they pass into the walls of the colon in a manner that will presently be described.

There is a great deal of variation in the length and course of these tubes, and the condition described above is to be regarded as the average condition rather than an exact description of the distribution of the tubes as found in any one individual specimen. Sometimes the vessels are much convoluted, at other times they seem to be nearly straight; in some cases they follow closely the windings of the second division of the mid-intestine in their course cephalad, and at other times they do not; often they do not quite reach the anterior end of the mesenteron and rarely they may even extend a little beyond into the prothorax. But the diameter of the vessels, and their color, a dull opaque white, are constant characters in this series.

The second series of vessels arises independently of the first, and some little distance in front. It consists of two isolated Malpighian vessels which enter the alimentary canal at the exact point where the mid-intestinal epithelium ends. Sections through the evagination of these tubes show typical mid-intestinal epithelium, but the sections immediately succeeding show the beginning of the hind-intestinal epithelium. These

two vessels leave the intestine side by side, and very close together, but are entirely independent of one another. It should not be inferred from any of the above statements that the writer regards the second series of tubes as appendages of the mid-intestine. The epithelium of that portion of the ileum into which both series of vessels empty is strikingly different from that of the remainder of this division of the intestine, and the cells of the Malpighian vessels are very different from those of the mid-intestine. The second series of vessels, as well as the first, belongs to the hind-intestine.

The two vessels which constitute the second series are very much shorter than the four tubes of the first series. They extend only a short distance anteriorly, usually following the twisting of the mesenteron, and then run more or less directly to the junction of the ileum and colon. Under the binocular these vessels appear more delicate than those of the first series, the diameter is slightly less, the cells are slightly smaller, and in color they are more or less a translucent white, instead of being opaque.

Thus far we have traced the course of the four vessels of the first series and the two vessels of the second series, and have seen that all six finally extend to the vicinity of the strong bend caudad in the alimentary canal, which marks externally the end of the ileum and the beginning of the colon.

The four vessels of the first series, which represent two pairs, at the distal ends of their coelomic portions unite into two common stems, consisting of two vessels each. One of the short vessels of the second series soon becomes closely associated with each stem, and thus all six of the tubes have now been accounted for. Each stem with its apposed vessel applies itself closely to the wall of the colon, one on the dorsal side and one on the ventral. Up to this point the vessels of the second series remain distinct, but here each fuses with the stem with which it is associated, and thus two common trunks, representing three vessels each, are formed, one lying on the dorsal wall of the colon and one on the ventral wall.

In *Haltica bimarginata* the colon consists of the following parts, passing toward the exterior: intima, epithelium, basement membrane, circular muscle layer, longitudinal muscle layer, (and later a layer of Malpighian vessels and a peritoneal

layer). All of the intestinal muscles, both circular and longitudinal, are clearly striated. The circular muscles are strongly developed in all but the posterior portion of the colon; there is a single row of them forming a continuous layer around the alimentary canal. The longitudinal muscle layer consists of six large fibres, which are rather regularly disposed, outside of the circular muscles.

Each vessel trunk lies between two of these longitudinal muscle fibres. As soon as the vessels have become appressed to the wall of the colon, their peritoneal sheaths grow out and join, so that a continuous peritoneal coat is formed, completely surrounding the colon, and enclosing the six muscle fibres and the two Malpighian trunks. As soon as this tunic is complete, each of the trunks redivides into three vessels, which almost immediately begin to "migrate" outside the muscle fibres so as to lie alternately with them. This "slipping" or "migration" extends through about twenty sections of six micra each before it is completed. The condition which results characterizes the greater part of the colon and in a typical cross section, one will find lying without the circular muscles, a layer composed of the six longitudinal muscle fibres alternating with the six Malpighian vessels, the whole surrounded by a nucleated peritoneum, probably of connective tissue, which, as it represents the investing sheath of the vessels, is a double layer. The two sheets separate at the vessels, one layer passing inside and the other outside of the tubes, but both sheets pass outside of the longitudinal muscles.

Figure 2 shows the Malpighian vessels after they have separated from the trunk "migrating" outside the fibres of the longitudinal muscles. Figure 3 shows diagrammatically a typical cross section of the colon. In reality the epithelium is not a syncytium.

In the more anterior part of the colon, the cross sections of the Malpighian vessels and of the longitudinal muscles are about equal in diameter. But as one traces the sections caudad, the Malpighian vessels gradually increase in size while the muscles decrease in size, and two thirds of the way to the end of the colon this has become very marked, the Malpighian vessels here being twice as large as the muscles. At this point the longitudinal muscles begin to diminish in size rapidly

and become very small, although they persist faintly to the end of the region. The circular muscles also decrease so markedly as to be almost negligible. The Malpighian vessels, which have been almost circular in cross sections, now become elongated along the diameter perpendicular to the axis of the canal, and tend to crowd the longitudinal muscles inside. This tendency becomes more and more pronounced, and some little distance before the end of the colon, the intestine is surrounded by a practically continuous layer of Malpighian tubes, with the small longitudinal muscles intercalated between them. The vessels do not extend along the wall of the rectum, but seem to terminate blindly at the posterior end of the colon.

It is very difficult to make out the exact course of the vessels in the walls of the colon in a dissected specimen. They seem to extend posteriorly as six parallel tubes, at first of slight diameter and almost straight; but, as was noted in the preceding paragraph, as the diameter increases, they become more and more wavy, with larger and larger folds. It is this character which makes the vessels appear so elongated in cross sections. Toward the end of the colon, these undulatory folds are so large that those of one series almost touch those of the adjacent series, and thus they almost completely surround the wall of the colon. The vessels seem to branch irregularly, the tubes terminating blindly and separately in irregular ramifications, just anterior to the strong circular muscles which appear abruptly, and mark externally the beginning of the rectum. The tubes in the wall of the colon have an extremely abundant tracheal supply, a fact which makes dissection difficult, and makes it much harder to trace them out.

The distribution and ramification of one of the Malpighian trunks in the wall of the colon is shown diagrammatically in Figure 4. It should be noted that the strong circular muscles which mark the beginning of the rectum are peculiar to that region, and there are no muscles overlying the Malpighian vessels in the wall of the colon.

We may summarize, then, the distribution of the Malpighian tubes in the larva of *Haltica bimarginata* as follows, beginning at their distal ends. Six Malpighian vessels extend parallel to one another, running cephalad in the wall of the colon. They unite at the anterior end of this region to form two common trunks, which leaving the wall of the intestine, split up

into a single tube and a common stem representing a pair of tubes. The single tube, which is very short and delicate, runs quite directly to the mesenteron, where it is inserted isolated into the wall of the intestine, just at the point of junction between the mid-intestine and the hind-intestine. Each common stem soon splits up into two vessels which have a long course through the body cavity. Eventually the four vessels unite to form a single common urinary bladder, which empties into the hind-intestine at a point a little posterior to the insertion of the two shorter tubes. This condition is shown very diagrammatically in Figure 5.

2. THE GENERAL STRUCTURE OF THE VESSELS OF THE IMAGO.

The Malpighian vessels of the adult beetle of *Haltica bimarginata* have exactly the same relations as have just been described for the larva.

3. A COMPARISON OF THE CONDITIONS IN *Haltica bimarginata* WITH THOSE DESCRIBED FOR CERTAIN OTHER COLEOPTERA.

Not one of the general features noted above, although very different in many respects from the typical arrangement in insects, is peculiar to *Haltica bimarginata*, but all of these relations have been described for other forms, although so far as the writer is aware, there has never been a single species of insect recorded in which so many of them were illustrated.

It has long been known that the Malpighian vessels may have two apparent terminations in the intestine. In all known cases the second termination is merely superficial, in the walls of either the colon or the rectum, and the vessels do not empty into the alimentary canal except at the point of their evagination.

So far as the writer has been able to ascertain, the earliest work in which there is any reference to such a condition is Ramdohr's paper, which appeared in 1811. He figured the alimentary canals of at least 22 genera of Coleoptera, representing 10 families, 2 genera of Neuroptera, 3 genera of Hemiptera, 1 genus of Lepidoptera, and 1 genus of Diptera, in which the Malpighian vessels become reassociated with the alimentary canal at their distal ends, although he did not discuss this point at length.

The next reference is to be found in the classic work of Straus-Durckheim on a scarabaeid, *Melolontha vulgaris*, which was published in 1828.

Léon Dufour seems to have been the first man who did extended work on the Malpighian vessels of insects, and was the first author to point out the fact that the posterior intestinal insertion of the Malpighian vessels is only superficial. In discussing the metamorphosis of *Mordella fasciata* (Coleoptera) he wrote in 1840: "* * * I have always thought that this insertion penetrated the tunics of the coecum or the rectum in such a manner that the vessels might discharge a portion of their products of secretion into the interior of the latter. It is thus that all entomotomists have regarded this point of anatomy. * * * The posterior or coecal insertion of the hepatic vessels of the larva of *Mordella* (and perhaps or probably of all insects) is only superficial. These vessels instead of emptying into the intestine * * * simply ramify and are lost in a hyaline membraniform tissue which surrounds it. * * *" (Pages 231 and 232).

Dufour published a memoir on the Malpighian vessels in 1843, in which he discussed this double insertion still further, and described the conditions as he found them in several chrysomelids. In speaking of *Donacia*, he said in part: "* * * These vessels, which lack a rectal insertion, differ between themselves in size and the manner of insertion; they have * * * only a ventricular insertion, and although they appear to be six in number, there are really but four vessels. Two, much thinner and handle-like (à anses) are inserted by their four ends into an ovoid sessile body, which is a sort of gall-bladder (vésicule biliaire); two others, shorter, larger, swollen, large-bellied (ventrus) in the middle and floating at one end, are implanted isolated at the extremity of the ventriculus on its superior face." (Page 156). In *Crioceris merdigera*, "* * * the rectal insertion takes place by two trunks of two branches, and by two isolated vessels; and the ventricular, first by a lateral gall bladder as in *Donacia*, which receives four vessels, and then by two other more delicate vessels, colorless and isolated." (Page 157). "In *Cassida* the four principal vessels are grouped, but not confluent for their ventricular insertion; this takes place in the ventral wall of

that organ; the thinner vessels are separately inserted. The fixation at the rectum is made by two trunks of three vessels as in the longicorns." (Page 157). "*Galeruca tanaceti* * * * have the four principal vessels inserted on the ventriculus by a single very short stump (souche) which does not deserve to be called a gall bladder, and fixed on the rectum by two well distinct trunks. The thin walled vessels have isolated insertions." (Page 158). On the same page the conditions are described for *G. lusitanica*, the only difference being that here the ventricular insertion of the four tubes of the first series is not by a bladder, but separately.

In a general way the conditions in *Haltica* agree with those described by Dufour. His generalization (page 154) that in tetramerous Coleoptera the posterior insertion is never unicauline (by one trunk) as in the great majority of the heteromerous, but is bicauline (by two trunks) or fasciculated, holds true for *bimarginata*, in which the bicauline condition exists. In *Crioceris*, in *Cassida*, and in *Galeruca* there are two series of vessels, a series of four large tubes, and a series of two smaller more delicate vessels, just as is the case in the alder flea beetle. In *Donacia* also, the two series of tubes can be recognized. In most cases the four vessels of the first series empty through a bladder (an urinary bladder of course and not a gall bladder) and there is a colonic insertion of the tubes as occurs in *Haltica bimarginata*. (Although Dufour always speaks of a rectal insertion of the vessels, he used this term loosely; and in reality all of his figures show the Malpighian vessels passing very clearly into the wall of the colon, or second division of the hind intestine, and not into the rectum, or third division.) In nearly every case which he figured, the vessels of the second series are isolated in their ventricular insertion.

The greatest differences appear when *Haltica bimarginata* is compared with *Donacia*. In both cases there are two series of vessels, the first series comprising four tubes, emptying into the alimentary canal by a common bladder, and the second comprising two shorter vessels with isolated insertions. In the latter insect, the four vessels of the first series unite at their distal ends, and it is for this reason that Dufour regarded them as really only two vessels, and referred to them as handle-like (vaisseaux à anses). The fusion of the vessels into two common

stems in the alder flea beetle is probably homologous with this fusion into two pairs in *Donacia*. In *Haltica*, these vessels enter the colon wall and terminate blindly there, whereas in *Donacia*, they are fused into two pairs which lie free in the body cavity throughout their extent, and they have no free distal ending.

The vessels of the second series also present a very marked contrast in the two forms, the only point of similarity being that in both species they are shorter than the first series, and have isolated insertions. But whereas they are slender and delicate in *Haltica*, they are large and swollen in *Donacia*, much larger than the tubes of the first series, a very unusual condition which has been reported for no other chrysomelid genus. The distal ends of the vessels lie in the wall of the colon *Haltica*, and free in the body cavity in *Donacia*.

In *Crioceris* the conditions are almost identical with the alder flea beetle, in so far as Dufour has described them. In *Cassida*, the ventricular insertion is very different, but the superficial distal insertion is very suggestive of the condition in *H. bimarginata*.

Although Dufour was the first to state the probability that the posterior insertion of the vessels is merely superficial in all cases, he does not appear to have been fully convinced that this was true, especially in *Myrmeleon formicarium*. It remained for Sirodot in 1858, who summarized the results of earlier workers in a very satisfactory way, to demonstrate that in all cases, not excepting *Myrmeleon*, the posterior insertion is absolutely superficial, the vessels simply ramifying in the wall of the canal. His final statement in regard to the matter was: "As a general conclusion, then, the extremities of the Malpighian tubes are either free or united in bundles, but always without any alteration of the independence of their lumen." (Page 261).

Schindler's paper in 1878 was the next important contribution to our knowledge of the Malpighian vessels. Summarizing the results of his own studies on Coleoptera and those of preceding writers, he said: "Where one finds six vessels, it is often the case that they unite with one another at their extremities into one or two apparently common stalks, and seem to empty into the rectum, which is however, never the case, for after the common stalk has penetrated the outer layer of the

canal, the vessels again separate and bury themselves, ending blindly beneath this coat." (Page 630).

Schindler also recorded the condition of the vessels in *Haltica nemorum*. "Léon Dufour has already pointed out that in *Donacia* two pairs of winding 'gall-vessels' empty into a single 'gall-bladder' on the side of the stomach, while two other isolated canals are inserted in the under part of the stomach. A very similar condition is demonstrable in *Haltica nemorum*. Here the first four urinary tubes—in this case blind-ended—empty into a pyriform bladder. The bladder, which is only a urinary bladder and not a gall bladder, measures 1.0 mm. in cross section, and empties through a stalk (Stiel), the urethra, almost 1.5 mm. long, into the upper end of the large intestine (Mastdarm). * * * Shortly above this insertion two more urinary tubes empty isolated into the pylorus." (Page 631).

While this account agrees in a general way with the condition of the tubes in *Haltica bimarginata*, it is very surprising to find such great differences in species belonging to the same genus. The bladder of *bimarginata* is proportionately smaller, and there is no stalk at all. Admittedly this is a minor character; but the fact that the vessels end distally in the wall of the colon in the one species and blindly in the body cavity in the other, is remarkable. Schindler makes no statement in regard to the comparative length of the two series of vessels in *nemorum*, and as he has evidently used the terms "large intestine" and "pylorus" loosely, it is impossible from his description to make an accurate comparison of the ventricular insertion in the two species.

In 1910 Poyarkoff published an article dealing with the metamorphosis of another chrysomelid, *Galerucella luteola*, in which he described the larval vessels. According to his statement, they are four in number and empty into the second division of the hind intestine at the end of a comparatively long coecum. (He recognizes four regions in the hind-intestine). These four vessels after a long course through the body pass into the wall of the colon, where two of them bifurcate, so that there are six vessels associated with this portion of the intestine (the third region). (Pages 337, 401-402 and 414).

The condition described above is entirely different from that in *Haltica bimarginata*, save that in the latter also there are

six vessels associated with the wall of the colon. However, the distribution of these vessels in the colon wall of *Galerucella*, according to Poyarkoff, is very similar to the alder flea beetle. In *Galerucella* they are at first small, and then they become larger, ramifying irregularly so as to form an almost complete layer around the canal. In his figures, the peritoneal envelope is shown passing around the Malpighian vessels and outside the longitudinal muscles, just as has been described above for *Haltica bimarginata*.

The most recent paper dealing with the general subject of Malpighian tubes is the valuable contribution of Gorka in 1914. He studied two genera of Coleoptera, *Gnaptor* (family Tenebrionidæ) and *Necrophorus* (family Silphidæ). In his general summary may be found the following conclusions: "The number of Malpighian vessels is six in *Gnaptor spinimanus* and four in *Necrophorus humator*. In *Gnaptor* the Malpighian vessels build a network on the walls of the rectum, yet without emptying into it. Out of this network, which is due to the union of the vessels in pairs after a long wavy course on the walls of the rectum, a single thick stem is formed. This stem does not represent a fusion of the Malpighian vessels, but only a very close apposition. The common stem then divides into two branches, each of which consists of three vessels. Finally these also separate out and empty after a short course through the body cavity into the intestine, at the boundary of the mid-intestine and the hind-intestine. The Malpighian vessels of *Necrophorus* end blindly. In all the beetles studied the Malpighian vessels empty into the mid-intestine, and not into the hind-intestine. A few epithelial cells follow behind the insertion of the Malpighian vessels in *Gnaptor*, which agree with the epithelial cells of the mid-intestine in every respect." (Pages 330 and 331).

Only in a very general way does this recall the condition in *Haltica bimarginata*. In the latter the vessels do actually fuse, and the two common trunks represent a real coalescence, not simply a close apposition of the tubes. There is no indication that the trunk is composed of three distinct vessels, but in cross sections it appears like an ordinary Malpighian tube, and is not of an appreciably greater diameter. In *Cassida*, as figured by Dufour (Ann. de. sci. nat. 1825, ser. 1, t. 4, pl. 8,

fig. 1) one would also infer that there was a fusion of the three vessels and not simply an apposition. However, Gorka states that under high magnification, even without sectioning it can be seen in *Gnaptor* that the fusion is only apparent and not real.

In *H. bimarginata* there is a bladder and a dimorphism of the vessels correlated with a difference in their insertion and in their length, features no one of which is found in *Gnaptor*. Finally it is very clear in *Haltica* that the vessels pass into the wall of the colon, while from the figures of *Gnaptor* it seems equally clear that it is actually the wall of the rectum into which the vessels penetrate. It is evidently the colon into which the Malpighian tubes pass in all of the figures of chrysomelid alimentary canals drawn by Ramdohr (1811) and Dufour (1823-25, 1840, 1843).

Moreover the vessels of the alder flea beetle are very clearly appendages of the hind intestine and not of the mid-intestine. One would need very conclusive embryological data to be convinced that the Malpighian vessels were really appendages of the mid-intestine and not merely associated with it secondarily.

4. THE FUNCTION OF THAT PORTION OF THE TUBES ASSOCIATED WITH THE WALL OF THE COLON.

While working on the larvæ of *Galleria mellonella* (Lepidoptera) in 1908, Metalnikov demonstrated that the cells in the "tubes contournees" (as he termed that portion of the Malpighian vessels associated with the wall of the colon) never pass through the cyclic changes characteristic of the cells of the free portion of the vessels, and indicatory of secretory activity, nor do they take up any coloring agents injected into the body cavity. He formulated the hypothesis that this part of the tubes constitutes a special excretory apparatus which eliminates such toxic substances as may have passed through the intestinal epithelium.

This is the opinion of Poyarkoff (1910) and substantially that of Gorka (1914) who further confirmed the fact that there is a difference in the reactions and function between the portion of the tubes lying free in the body cavity and the portion associated with the hind intestine.

There seems no reason to doubt that the close association of the Malpighian vessels with the walls of the colon is for the purpose of excreting toxic products just as these authors have already pointed out. In *Haltica bimarginata* it is probable that most if not all of the digestion and absorption takes place in the mid-intestine. It also seems very likely that on account of the strong continuous layer of circular muscles the liquids absorbed do not at once pass into the body cavity, but flow backward between the basement membrane and the circular muscles. It may well be true that the greater part of this material does not pass outside the circular muscle layer until well along in the colon. Here its passage into the body cavity would be retarded by the peritoneal sheath which completely surrounds this region, and the absorbed liquids would thus be brought into close contact with the distal ends of the Malpighian vessels, which lie closely pressed against the muscle wall of the colon. Here doubtless such poisons and other harmful substances as the intestinal epithelium has allowed to pass through it are taken up by the cells of the Malpighian vessels and excreted before they have had any chance to pass into the body cavity of the insect.

The writer wishes to acknowledge his indebtedness to Dr. W. A. Riley of this Department, under whose general direction the work was carried on, for numerous suggestions and helpful criticisms.

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EXPLANATION OF PLATE.

FIGURE 1. The alimentary canal of the larva of *Haltica bimarginata*.

b—urinary bladder.
c—colon.
cr—crop.
i—ileum.
m_1 first division of the mid-intestine.
m_2—second division of the mid-intestine.
o—oesophagus.
p—pharynx.
r—rectum.

The walls of the alimentary canal are represented by dotted lines.

The course of the four Malpighian vessels of the first series is shown by wavy lines.

The course of the two Malpighian vessels of the second series is shown by solid lines.

FIGURE 2. Diagrammatic cross section of the colon showing the Malpighian vessels migrating around the longitudinal muscles.

i—intima.
e—epithelium.
cm—circular muscle layer.
lm—longitudinal muscle fibres.
mv—malpighian vessels associated with the colon.
pe—peritoneal envelope.

FIGURE 3. Diagrammatic cross section of the colon showing the typical alternation of Malpighian vessels and longitudinal muscles.

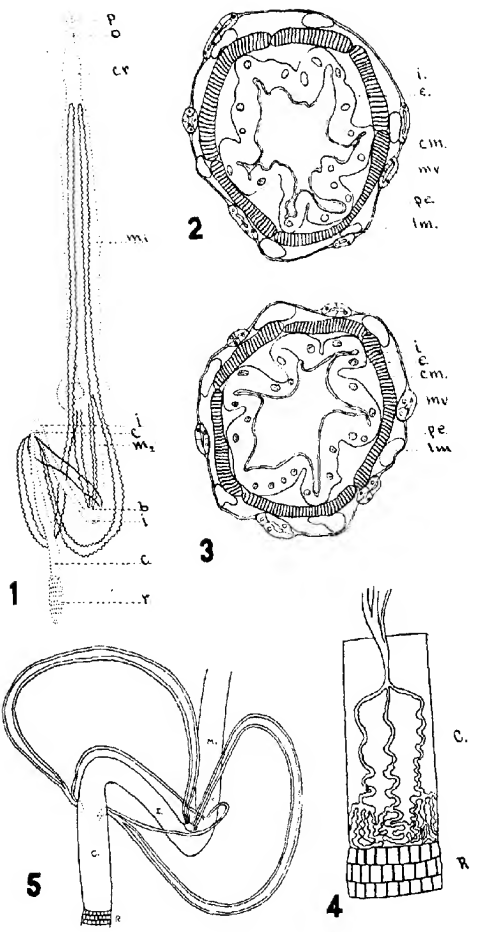
i—intima.
e—epithelium.
cm—circular muscle layer.
lm—longitudinal muscle fibres.
mv—malpighian vessels associated with the colon.
pe—peritoneal envelope.

FIGURE 4. Diagram showing the ramification of one of the Malpighian trunks in the wall of the colon.

C—colon.
R—rectum.

FIGURE 5. Scheme showing very diagrammatically the insertion and relation of the two series of Malpighian vessels.

C—colon.
I—ileum.
M—mid-intestine.
R—rectum.



William C. Woods.

THE ATTRACTION OF DIPTERA TO AMMONIA.

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During the course of experiments on the responses of the house-fly to certain chemical compounds, data were gathered concerning the reactions of some other species that entered the traps with more or less regularity. It is the purpose of this article to give the results of these experiments and to include brief summaries of the literature concerning the olfactory tropisms of insects.

It has long been recognized that the olfactory organs of insects are of primary importance in the search for food and for breeding places, in the assembling of the sexes, and in the reactions to certain repulsive smelling substances. The experimental study of these responses to environmental odors, neglected by entomologists in the past, has recently awakened an interest which promises important results.

Tragardh (1913) and Imms (1914) have published in England valuable resumes of the literature touching upon this subject, but I believe no fairly comprehensive bibliography has yet been placed before American students.

One of the earliest contributions to odor responses was made by Barrows (1907) on the pomace-fly, *Drosophila ampelophila* Loew. It was found that the flies responded positively to aqueous solutions of amyl alcohol, ethyl alcohol, acetic acid, lactic acid, and acetic ether. When acetic ether was added to acetic acid or ethyl alcohol, more flies were captured than when acetic acid or ethyl alcohol was used alone. A similar phenomenon was observed when isobutyl acetate or methyl acetate was mixed with ten per cent ethyl alcohol or when acetic, butyric or valerianic acid was added to ethyl alcohol. The strong mineral acids, nitric and hydrochloric, were very repellent. A solution containing two and one-half per cent. of ethyl alcohol and five-eighths per cent. of acetic acid called forth the greatest number of positive reactions. Ethyl alcohol and acetic acid are found in cider vinegar, fermented cider and California sherry in percentages close to those which induced maximum

reactions in *Drosophila*. The author ascertained also that the olfactory organs in *Drosophila* which are concerned with the location of food are situated in the third or terminal segments of the antennæ. When stimulated by a weak food odor the flies responded by random movements, but as they passed into an area of greater stimulation, they became directly oriented and proceeded toward the source of the odor.

Verschaffelt (1910) has published an important paper on the compounds that determine the selection of food in larvæ of *Pieris brassicæ* and *Pieris rapæ*. These larvæ feed upon certain Cruciferæ as well as *Tropaeolium* and *Reseda*, plants which contain a group of glucosides, the mustard oils. A solution of sinigrin, one of these mustard oils, when spread upon foliage which the larvæ ordinarily refused caused them to devour it readily. The larvæ of a sawfly, *Priophorus padi*, which feed upon the leaves of certain Rosaceæ, were attracted by amygdaline, a glucoside found in these plants.

Howlett (1912) attracted fruit-flies of the genus *Dacus* to rags moistened with oil of citronella. Only the males responded to this odor and he was able to show quite conclusively that the females emit an odor closely resembling the oil of citronella. In other experiments he induced a species of *Sarcophaga* to deposit larvæ in a flask containing a solution of skatol, a compound present in the feces of many animals. He also found that *Stomoxys calcitrans* L. would oviposit on cotton-wool which had been soaked in valerianic acid and that both valerianic and butyric acids were similarly attractive to an ortalid fly of the genus *Ulidia* (?). The work was done at Pusa, India.

The same author (Howlett, 1914) demonstrated the attractiveness of benzaldehyde, cinnamylaldehyde and anisaldehyde to two undetermined species of thrips. Salicylaldehyde and isobutylaldehyde were also tried, but the results from these were not so striking. The experiments were conducted in England during the months of November and December, when thrips are not abundant. The author believes larger catches would be obtained in summer.

The Severins (1914, a and b), have studied the attractiveness of various oils to the Mediterranean Fruit-fly, *Ceratitis capitata* Wied. in the Hawaiian Islands. Kerosene was used as a bait in many experiments and it was found that most of the flies captured were males. Indeed in eight month's trapping an

average of only three females was obtained in every thousand flies caught. Traps were colored white, black, blue and orange, but the size of the catches did not appear to depend on the color of the trap. Traps placed under trees whose fruits had a readily accessible supply of juice (Java plum) caught the largest number of flies, but flies were often caught in traps wired to trees not in fruit or which bore fruit not sought by the flies. Petroleum oils containing comparatively large amounts of volatile hydrocarbons were most readily sought while the heavier burning and lubricating oils were less attractive. Oil of citronella and turpentine had a very slight attraction, cocoanut oil had none. Whale and fish oils were not visited by the flies. The alluring properties of petroleum oils are probably due to one or more of the volatile hydrocarbons or to some of the impurities such as the sulphur or nitrogen constituents. While admitting that these attractive oils may give off an odor which resembles that emitted by the female fly, it is stated that the tropism may be one not associated with sex.

Chatterjee (1915) found that kusum oil from the berries of the tree, *Schleichera trijuga* attracted nymphs and adults of both sexes of a coried, *Serinetha augur*. A few drops of the oil scattered about on any suitable object was sufficient to allure large numbers of the bugs. The experiments were conducted at Dehra Dun, India.

I have recently published results of experiments on the attractiveness of ammonia and certain other chemical compounds to the house-fly *Musca domestica* L (Richardson, 1916, a. and b.). Ammonia from commercial ammonium carbonate and ammonium hydroxide was attractive to females, but was visited by few males. Eggs were deposited on the following materials when ammonium carbonate was added to them: acidulated horse manure (treated with dilute hydrochloric acid so that all the volatile ammonia was converted into the non-volatile ammonium chloride), moist timothy chaff, moist pine sawdust and moist cotton. However cotton was scarcely attractive without further addition of butyric or valerianic acid. Horse manure was the most attractive, pine sawdust and cotton the least. The house-fly apparently has some means of discriminating between substances which can and those which can not furnish food for its larvæ.

It will be noted that the activating substances where their exact chemical nature has been determined, are for the most part organic compounds, some of considerable complexity. Ammonia is the only one among these which is not a carbon compound, and it is the simplest in molecular structure.

THE EXPERIMENTS.

The flies were captured in screen wire traps nine and three-fourths inches high and six inches in diameter at the base. Pieces of commercial ammonium carbonate were placed in glass dishes in the pan of the trap and a little water was usually added to each glass dish. Ten experiments involving twenty-three traps, each containing from eighty-five to two hundred and thirty-four grams of ammonium carbonate and seventeen controls with or without water were carried out during the summer. The results, exclusive of house-flies caught are given in the following table:

TABLE A.

	Traps containing ammonium carbonate Number caught	Control traps Number caught
Phorbia sp.	15	
Muscina stabulans	11	
Ravinia communis	1	2
Fannia canicularis	1	
Lucilia sericata	1	1
Ophyra leucostoma	2	
Stomoxys calcitrans	3	
Leptocera ferruginata	106	
Sepsis minuta	2	

An ortalid, *Leptocera* (*Limosina*) *ferruginata* Steub. was a frequent visitor to the traps and an undetermined *Phorbia* and *Muscina stabulans* Fall. were caught often enough to suspect they were attracted by the odor of ammonia. *Leptocera* is so small that it can pass through the meshes of the trap screen readily and only those individuals that fell into the solution were captured. Had the meshes been small enough to retain the flies which entered the traps, I believe the number would have been far larger. In the oviposition experiments with the house-fly, *Leptocera*, was almost always present, running about in the dishes containing ammoniated manure, timothy chaff and pine sawdust and even coming to those which held the ammoniated cotton. It was an abundant species in accumulations of horse manure at New Brunswick. *Sepsis minuta* Wied.

was also seen about the traps and experimental dishes frequently, but for some reason few individuals were caught. Several other species were captured in small numbers, but have not yet been identified.

Stomoxys calcitrans L. was not caught often in ammonia traps and I was not able to get it to oviposit on cotton soaked in valerianic acid, although Howlett did succeed in this at Pusa, India. Howlett does not give the details of his experiments further than to say that he used "cotton-wool soaked in valerianic acid." (Howlett, 1912, p. 416).

One trap experiment and eight oviposition experiments with valerianic acid were completed during the summer of 1915 at New Brunswick. The traps and method of using them have been described above. The oviposition experiments were performed in porcelain evaporating dishes, 120 mm. in diameter. A piece of sterilized absorbent cotton was placed in each, to the surface of which the acid and usually water were added. The experiments were carried out at various times on the window sills of a laboratory or on a bench near a livery stable. Frequent observations showed that *Stomoxys* was present in these localities throughout the course of the experiments. The results of the valerianic acid experiments are set forth in the following table:

TABLE B.

TRAP EXPERIMENT.

Amount of material.	Number of traps	Duration of experiment	Result
50 cc. valerianic acid	1	67 hrs.	No *Stomoxys*
50 cc. distilled water	1	"	"

OVIPOSITION EXPERIMENTS.

Amount of material	Number of experimental dishes	Duration of experiment	Result
10 cc. valerianic acid+cotton	1	46 hrs.	No eggs
2 cc. valerianic acid+cotton+50 cc. water	1	45 hrs.	"
5 cc. valerianic acid+cotton+50 cc. water	1	45 hrs.	"
" " " "	1	46 hrs.	"
" " " "	1	23 hrs.	"
" " " "	1	22 hrs.	"
" " " "	1	18 hrs.	"
" " " "	1	3 hrs.	"

Stomoxys did not lay eggs on cotton treated with valerianic acid in these experiments and it was never seen attempting to do so, nor was it ever observed hovering about the dishes.

The odor of two cubic centimeters of the acid diluted with fifty cubic centimeters of water was easily perceptible to a man at a distance of fifteen feet from the dish.

While my results do not agree with Howlett's, this may be due to the fact that we used different methods, or even to some dissimilarity in the responses of *Stomoxys* in the two regions. One can conceive of the same species of insect attuned to respond to certain odors in one environment, responding to very different odors in another.

CONCLUSION.

The odor of ammonia attracts a varied dipterous aggregation. The species which respond to it are known to spend at least a part of their lives in some form of animal excrement. Practically all animal excrement gives off ammonia during some stage in its decomposition. These flies are probably lured to the manure chiefly by the odor of this gas. The response is not always a simple one, but is sometimes complicated by other factors, as has been shown in the studies on *Musca domestica* L. referred to above.

I am indebted to Mr. J. R. Malloch for the identification of several species of Diptera.

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THE SPECIFIC EFFECTS OF CERTAIN LEAF-FEEDING COCCIDAE AND APHIDIDAE UPON THE PINES.

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In the great volume of entomological literature, we find but few references dealing with the specific effects of the attacks of sucking insects upon the tissues of their hosts. Statements describing the appearance of the work to the naked eye are, at most, meager in detail; and there are few records of morphological and chemical study of the affected plant tissue and of histological study of the parts of the insects concerned. The present paper summarizes the results of a year's work in the Entomological and Botanical laboratories of Stanford University on a few species of plant-sap sucking insects living on the needles of the pines and the precise character of the results of their work.

Over a year ago we became interested in finding the cause of certain, peculiar, light spots on the needles of the various species of pine found in California, the presence of which has not heretofore been explained. Also, it was noticed that light, greenish-white areas frequently surround scales of *Chionaspis pinifoliæ* Fitch, the white pine scale, and of *Aspidiotus abietis* Schr. (*A. californicus* and *A. florenciæ* Coleman), giving the leaves of a badly infested tree a mottled, sickly appearance. Later, these spots were observed to turn brown, often killing large numbers of the needles. The purpose of this investigation was to find an explanation for these phenomena.

The study of the insects *in situ* is of primary importance in working out this problem. Two methods suggest themselves: (1) observation of the insect at work and of the wounds made on the plant. The latter should be observed immediately after the insect has stopped feeding and at intervals later to determine the ultimate effect of the sucking upon the metabolism of the plant. Another method, (2), is morphological study of the insect and its work by means of sections through the affected tissues and the beak of the insect. Both of these methods have been used in the investigation here summarized.

It has been necessary to develop or adapt several points in microtechnique in order to use the second of these two methods, i. e., morphological study. These points have been discussed in an article* which recently appeared in *Science*.

I. The White Pine Scale, *Chionaspis pinifoliæ* Fitch.

The white pine scale, *Chionaspis pinifoliæ* Fitch, is a conspicuous and widespread pest of pines in North America. It is, as a rule, particularly common on transplanted trees. In the East, the most important host is the white pine, *Pinus strobus*, which it has attacked wherever this pine is grown in North America, often proving a serious pest. It has done great damage to the Monterey pine, *Pinus radiata*, in California.

The white pine scale is entirely a leaf feeder. The flat side of the needles is usually occupied, but in a serious infection the rounded surface is covered as well. As a rule, a single row will be found along a needle, the scales occuring in groups.

As seen in Photograph I, wherever a scale or group of scales occurs, a light colored area with much less chlorophyll than usual is found. It is evident that this is due, primarily, to the sucking of the insects. After many months of sucking, many of the light-colored areas die and dark, reddish spots appear. One of these spots is shown on the upper needle in Photograph I, directly under the scale. Later the needles change from the mottled appearance they have had for some time to a uniform, sickly, yellow color and finally die. Great numbers of the scales are attacked by parasites, but these usually come too late to be of service in checking the damage done by the particular insects they parasitize. It is evident that they partially overcome the enormous increase of which this insect is capable. Lady bird beetles, including *Chilocorus bivulnerus* Muls., the two-stabbed lady bird, are usually of great help.

The amount of damage which a pest does is in direct proportion to its numbers. An insect may be widespread, but it may be held in check so that it is usually of comparatively small importance. Occasionally this species becomes abundant enough to cause great damage. We find that when for any cause the trees are at all weakened, for instance by fire or lack of

*Brown, Kearn B., Microtechnical Methods for studying certain plant-sucking insects *in situ*. Science, N. S. Vol. XLIV, p. 758, 1916.

sufficient water, the damage from the scales is much more noticeable. It is rarely that trees are actually killed by its attacks.

It is not an easy matter to estimate the amount of damage by such a pest, even when it occurs in such countless numbers as on the Monterey pines at Stanford University. The amount of damage may be estimated by determining the per cent of leaf tissue which has lost its chlorophyll by the sucking and the additional percent of leaf tissue lost by the death of the needles long before their normal time for dying. Our records for *Pinus radiata* in the Stanford arboretum indicate that approximately five per cent of leaf tissue is destroyed in these two ways by *Chionaspis pinifoliæ* Fitch. This injury, together with that caused by the other pests of the Monterey pine, such as *Diplosis pini-radiatæ* Snow and *Physokermes insignicola* Craw so weaken the trees that they fall an easy prey to the Scolytid beetles.

A morphological study of a normal Monterey pine leaf shows its structure to be as follows: On the outside is the epidermis, a single layer of cells through which the stomata, or breathing pores, pass to the tissues underneath. Under the epidermis is the schlerenchyma, a strengthening tissue made up of several layers of heavy-walled cells. Next is the mesophyll with characteristically infolded outer walls, the cells of which contain the chlorophyll granules. There are two resin ducts, one located at a point inside each angle made at the union of the rounded and flat surfaces of the leaf. The resin ducts are surrounded by a double row of resin-secreting cells. Inside the mesophyll is the bundle sheath surrounding the stele with its two parallel vascular bundles. All the tissues described above are shown in Photomicrograph No. II.

Examination of the photomicrographs II and III will show what the insect does to the plant. The four sucking and piercing setæ of the coccid, which are the modified mouthparts of this family, enter the needle either by spreading apart the epidermal cells or at an open stoma. Photograph III shows that schlerenchymatous cells have been bored through. The appearance of the cells around the setæ indicates that this insect, in common with some other members of the family and the *Aphididæ*, uses saliva to dissolve a passage through the hard walls. This section shows that a sheath has been formed around the setæ.

This sheath consists of viscous saliva and passes through the whole of the open space that has been formed by the solvent action of the saliva to a cell that has just been attacked and where fresh saliva has just been poured out to dissolve the cell wall and contents. As soon as a cell has been pierced, its turgor, or pressure from the inside, which is several atmospheres, gives away. The cell's liquid contents is partly forced by the pressure of the surrounding cells and partly leaks out into the open space. It is then sucked up into the insect's body.

Plateau* has shown that the saliva of *Hemiptera* has the power to change starch to sugar. We have proven that this coccid is no exception by the tests made on cells that had just been pierced by the insect. We get negative results with iodin as a test for starch, but Fehling's solution, a test for sugar, gives positive results. The presence of proteid-dissolving and cellulose-dissolving enzymes in the saliva is indicated by the destruction of the cells of the plant by its work. Most of the nutriment is obtained from the mesophyll tissue. This is shown by the number of cells broken up and destroyed or partially destroyed in all of the many sections examined. So we place *Chionaspis pinifoliæ* Fitch in the second class of sucking insects described by Busgen,† "those piercing into the parenchyma by boring through the cells."

It is not possible to say positively whether there is an actual poisoning to the plant by one or more of the enzymes that are injected into its cells. The following evidence points toward such conclusion: The mesophyll tissue is first discolored, then browned and killed, as shown in photomicrograph IV. The killed and discolored mesophyll cells are those shown darkest in the photograph. The mesophyll region near the upper side of the illustration would appear exactly the same as the corresponding area near the lower margin, if the scale had not been sucking in the vicinity of the darkened cells, thereby killing them. This dead tissue extends for a distance much greater than the beak can pierce.

It is not likely that these cells are merely dried out and starved by withdrawal of liquid coming up from the roots,

*Plateau, Recherches sur les phenomenes de la digestion les insectes. 1874. Bruxelles.

†Busgen, M., Der Honigtau, Jenaische Zeitschrift fur Naturwissenschaft, Bd. 25, p. 381, 1891.

because, so far as it is possible to see, the fibro-vascular bundles are not in any way injured. It is probable that the xylem functions in an infested leaf as in a normal one, supplying water and raw materials.

Our research goes to show that one effect on the pines of the work of various insects is only accidental. This is the piercing of the resin duct or of the cells so close to it that the resin becomes infiltrated through a part of the leaf, giving it a white, spotted or banded appearance. That this occurs but rarely in the case of *Chionaspis pinifoliæ* Fitch is explained by the common location of the insects in a single row along the needles, with the beaks entering the leaf tissue at points remote from the resin ducts. In the section shown in photographs II and III, the saliva has dissolved tissue not more than two or three rows of cells distant from the resin duct.

II. *Aspidiotus abietis* Schr.

Another of the economically important *Coccidæ* affecting the conifers is commonly known as the black hemlock or pine scale, *Aspidiotus abietis* Schr. (*A californicus* and *A. florenciæ* Coleman). Observation of trees badly affected by this scale shows that it does great damage at certain times. At Campo Seco, Calaveras, Co., California, we* found it in 1915 the most abundant scale of the region, stunting and killing large numbers of digger pine, *Pinus sabiniana.*

The appearance of *Aspidiotus abietis* Schr. on the trees and the damage it does is shown in photograph V. The damage, a mottling of the needles followed by browning and dying, is similar to that of *Chionaspis pinifoliæ* Fitch. Great numbers of the leaves fall. The remaining leaves are often so sickly looking, or so many are browned, that whole groves of affected trees may look as if a fire had singed the leaves. One noticeable difference from the work of *Chionaspis pinifoliæ* Fitch is the large number of spots which have lost all chlorophyll. These spots are often one-fourth of an inch in length and extend, in some cases, around the needle. These spots will be discussed later as "infiltrated spots."

*Brown, Kearn B., Rpt. of Entomologist and Pathologist on Pests and Diseases of the Campo Seco, California, Region. 1915.

Morphological study of infested needles shows that the manner of sucking is similar to that described above for *Chionaspis pinifoliæ* Fitch. Photograph VI of the setæ *in situ* in a needle of *Pinus sabiniana* gives an idea of the first stage of the work. Owing to the size of the scale and the shape of the needles of many of the hosts, this scale frequently pierces the resin ducts accidentally. Credit for this discovery is due to Mr. E. A. Cornwall, graduate student in Entomology at Stanford University, who, in preliminary work in this investigation, cut sections showing this. The "infiltrated spots," caused by this tapping of the resin duct, are similar to those due to aphid attacks and shown in photograph VIII. A section of digger pine needle, showing killed cells infiltrated from broken resin duct is shown in photomicrograph VII.

III. *Aphididæ* on Pines.

Several species of *Aphididæ*, or plant lice, infest the pines, including, at Stanford University, *Lachnus pini-radiatæ* Davidson and *Essigella californica* Essig. As but little is known of the effects of conifer-feeding *Aphididæ*, we have made careful, daily observations of these species for a period extending over six weeks. We aimed to find out their habits and to determine, if possible, whether there is any relation between the aphid attacks and three abnormal conditions found on infested needles. Examples are shown in Photograph VIII. They may be described as:

(1) minute white spots;

(2) gumming, apparently from small leaf punctures;

(3) infiltrated spots similar to those described above on page 418. Some of the infiltrated spots show a reddish area in the center of one side, either as a small red mark or as large spots of dead tissue.

Lachnus was found to be a comparatively sedentary species. It seldom removes the beak from the tissues, often remaining in one position for weeks at a time, even in stormy, windy weather. It is conspicuous, usually being found in colonies of two to six apterous females, the progeny of one stem-mother, on one side of the needle. The whole colony is not over an inch in length. The part of the leaf where they are working is covered with gray, waxy secretion. The leaves finally

get a coating of black, sooty mold, which grows in the honeydew excreted by the aphids. Both the gray secretion and the sooty mold fungus greatly injure the appearance of infested Monterey pines. Frequently, when a colony of *Lachnus* is rubbed off, small, discolored areas where the beaks have penetrated are disclosed. A large specimen which has been parasitized and killed is shown in Photograph IX. This also shows the final effects of the work, a discoloration of the needle where the insect had sucked. The reddish area extends entirely around the needle. A light green area is shown on either side of this red spot.

Essigella was found to be an active species, the individuals sucking for a day or two in a place, retreating to a protected position at the base of the needle bundles at the slightest disturbance, and also remaining hidden there in wet, windy weather. Detailed, daily observations of all individuals on a number of selected needles were made for a period of six weeks.

Selecting examples at random from our records of *Essigella*, we find that punctures were made during this comparatively short period in 83 places on one leaf, and 74 on another, though the number of aphids on a leaf at the time the observations were made was, on the average, five. Conclusions drawn from the observations are as follows:

(1) Out of about 6400 feeding positions observed, but few left any mark that was visible to the eye, except sooty mold. This was removed at the end of the observation period to make it possible to find any markings there might be beneath.

(2) *Two* feeding positions, in each case of one day only, were followed by an exudation of gum. We made sections to find the cause of the exudation. Both were shown to be caused by a puncturing of the resin ducts. This is apparently accidental, as they would be as poor feeding ground as could be found in the leaf.

(3) *Three* cases of infiltrated spots occurred. One was accompanied by gumming. All were the same as other infiltrated spots found on aphid- or coccid-infested pines.

(4) There were *ten* small, light colored spots which, in every case, followed a period of sucking of two or more days.

Experiments were tried to determine whether infiltrated spots could be produced artificially. Selected digger pine

needles were pricked in the region of the resin ducts with Minutien-Nadeln, which are very small needles, commonly used for pinning tiny insects. Effects of the punctures were noted as follows: Out of 20 pricks, *four* showed an exudation of gum. After two weeks two of these gave evidence of infiltration. At the end of the second week, the spots were small. They continued to grow larger.

IV. Conclusions.

We can say, therefore, that the damage to the needles of pine trees by aphid feeding is:

(1) From the honeydew fungus, which makes the trees unsightly and interferes with the process of photo synthesis, or food manufacture, in the needles by shutting off part of the light;

(2) By discolored areas from which food has been taken and which have been whitened by admission of air to the cells;

(3) By the making of conspicuous, infiltrated spots and causing gum exudation;

(4) Inconspicuous damage by the great number of piercings and suckings. This, though usually invisible, is probably more important than the first three taken together.

The damage to pines by the coccids studied is due to sucking and the enzyme action of the saliva injected to assist in this process. The damage consists of the destruction of chlorophyll-bearing cells with a subsequent whitening of the needles. This is followed by the death of the needles in some cases, or, occasionally, by the production of infiltrated spots that, while conspicuous, are not of great importance.

EXPLANATION OF PLATES XVIII AND XIX.

Fig. 1. Effect of *Chionaspis pinifoliæ* Fitch. On needles of Monterey pine. (x3). On needle above, the red area (very dark in photograph) shows where the beak has punctured. A light green area extends for some distance on either side of this spot. Several of the scales shown in the needle below have been parasitized.

Fig. 2. Photomicrograph of section of Monterey Pine Needle (x60) showing beak of *Chionaspis pinifoliæ* Fitch *in situ* (in open space in upper right hand corner).

Fig. 3. Photomicrograph of beak of *Chionaspis pinifoliæ* Fitch, in section of Monterey pine needle (×360). Same as Photograph II, more highly magnified. The setæ, which form a sheath of saliva as soon as they enter the leaf, are shown in position, also the effect on the leaf tissues. The setæ have entered the leaf on the upper side, passed through the epidermal and schlerenchymatous cells, and entered the mesophyll region. The open space shows that most of the cells have been dissolved, with some of the cell walls not yet completely destroyed, while those on the extreme left of the photograph that are not in direct contact with the saliva are in normal condition. During the preparation of the section, the setæ were accidentally broken from the body of the insect near the point where they entered the leaf tissues.

Fig. 4. Photomicrograph of a longitudinal section of a leaf of Monterey Pine (×60); the mesophyll tissue near the upper margin of the photograph has been killed and discolored by *Chionaspis pinifoliæ* Fitch.

Fig. 5. *Aspidiotus abietis* Schr. on needles of digger pine, showing adult and young scales *in situ* (×3). The light-colored areas on the leaves are the effect of the sucking.

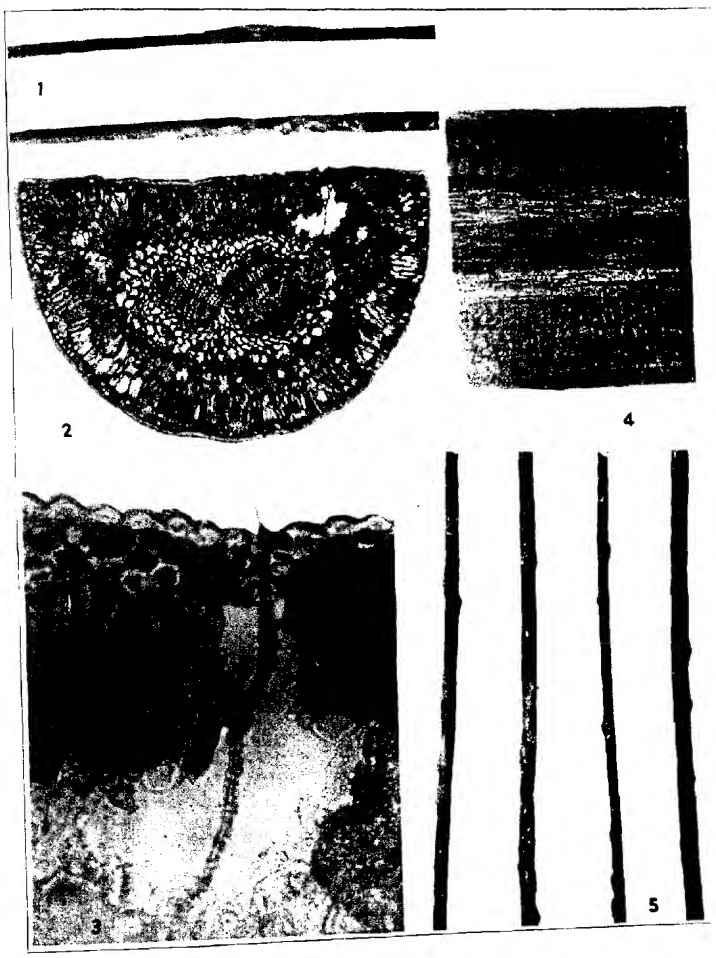
Fig. 6. Photomicrograph of stained section of digger pine leaf (×360), showing beak of *Aspidiotus abietis* Schr. *in situ*. The sucking setæ have just entered the mesophyll tissue, hence no large open space has been dissolved. One cell has been killed. The cell from which the coccid was sucking at the time it was killed and sectioned is partially filled with saliva. A drop of the saliva may be seen near the distal end of the setæ.

Fig. 7. Photomicrograph of a section of digger pine needle (×120) showing killed cells infiltrated from broken resin duct, the large open area a little to the right of the part of the section photographed. All the mesophyll cells above and to the right of the duct have been infiltrated. There is a distinct line separating them from the non-infiltrated area.

Fig. 8. Effects of aphid sucking on digger pine (×3). Needles 1 (on left), 2, 5, and 6 show small, white areas; 2, 3, 4, and 6 show infiltration. The spot on needle 3 is without exudation, but has a red center.

Fig. 9. Parasitized *Lachnus* on Monterey pine needle, with results of sucking. (×3).

NOTE: In making the plates the author's photographs have been slightly reduced, hence measurements given above are only approximate.



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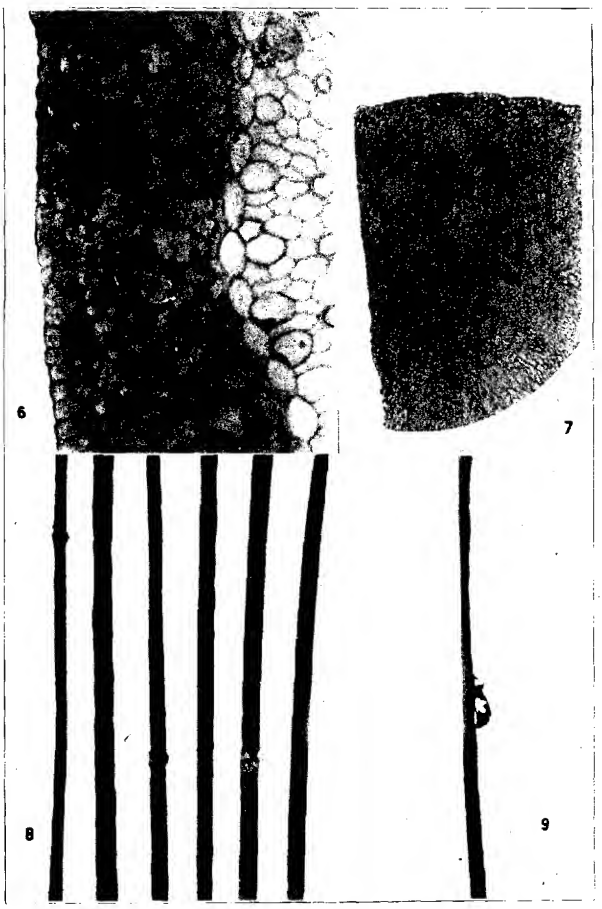

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